Respiratory, Autonomic and Emotional Responses to Affect Manipulation in High and Low Trait Anxiety

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Declaration

I declare that this thesis is my own work and that, to the best of my knowledge and belief, it does not contain material from published sources without proper acknowledgment, not does it contain material which has been accepted for the award of any other higher degree or graduate diploma in any university.

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Abstract

Investigations concerned with the autonomic characteristics of generalised anxiety disorder (GAD) patients indicate the influence of parasympathetic nervous system activity on heart rate is unresolved. As a result, the use of parasympathetic measures in GAD research may be of value. The functional physiology of respiration was reviewed and the importance of calibration procedures associated with respiratory inductive plethysmography for measuring respiratory mode excursions relative to volume changes was detailed. Findings from studies investigating involuntary respiratory changes indicate links exist between anxiety and fear states, personality predispositions and respiratory mode contribution differences. Specifically, rapid, shallow (thoracic (TH)) breathing may be associated with trait-anxiety. The conceptual framework of reversal theory is increasingly being used to explain the dynamics of emotion, stress and anxiety related behaviour. Experimental evidence demonstrates that telic dominance is associated with trait-anxiety. The process of inhibited reversal was used to explain how chronic anxiety could develop in telic dominant individuals.

Generalised anxiety disorder (GAD) is often a life-long, characterological trait and is a consistent component of many anxiety disorders (Nathan & Gorman, 1998). It is characterised by excessive and uncontrollable worry, and is accompanied by such prominent somatic symptomatology as; muscle tension, easy startle and hypervigilence (see Diagnostic and Statistical Manual of Mental Disorders (4th ed.), abbreviated as DSM-IV, American Psychiatric Association, 1994). It has been suggested that individuals with generalised anxiety use verbal conceptual activity, in the form of worry, to distract themselves from more upsetting thoughts that are likely to be more anxiety producing (Borkovec & Inz, 1990). The use of this strategy may be problematic in that it blocks emotional processing (Foa & Kozac, 1986), which increases the likelihood of intrusive thoughts as a result of failed emotional processing.

The term anxiety, as defined by Spielberger (1983), may be applied in two contexts; one describes a negative or unpleasant emotional state (state-anxiety), the second describes a personality trait that relates to "relatively stable individual differences .... in the disposition to perceive a wide range of stimulus situations as dangerous or threatening" (trait-anxiety) (Spielberger, 1983, p. 5). Trait-anxiety also reflects the frequency and intensity with which anxiety has been experienced in the past, which predisposes the individual to experience anxiety in the future. According to Rapee (1991) trait-anxiety becomes a disorder when it interferes with the functioning of the individual. Compared with other anxiety disorders, and despite its high prevalence, GAD is one of the least studied anxiety disorders (Nathan & Gorman, 1998). Owing to its chronic nature, treatment is often met with only modest gains (Brown, O'Leary, & Barlow, 1993). Consequently, research that increases the understanding of the nature, maintenance and reduction of GAD is likely to lead to treatment gains and have broad applications to other anxiety disorders.

The symptoms of stress and anxiety have been linked to respiratory dysfunction, particularly to hyperventilation (Grossman, De Swart, & Defares, 1985; Huey & West, 1983; Lum, 1975). Panic disorder and agoraphobia have also been linked to respiratory dysfunction (Clark, Salkovskis, & Chalkley, 1985; Bonn, Readhead, & Timmons, 1984), and studies into stress and anxiety have demonstrated distinct respiratory patterns associated with these states (Boiten, Fridja, & Wientjes, 1994). The possibility that respiratory parameters are implicated in GAD provides the impetus to review literature pertaining to this matter.

GAD and autonomic responses

Before the DSM-III R (APA, 1987, p. 253) was revised in 1994, "autonomic hyperactivity" was listed as a GAD symptom criterion. Research findings were frequently at odds with this criterion when autonomic responses, particularly heart rate (HR) responses, were lower in GAD sufferers than controls. Borkovec and Hu (1990) found decreased HR responses to phobic image exposure in GAD patients. They concluded that GAD sufferers were "autonomic restrictors" (p. 72). Other researchers have described GAD patients' autonomic responses in similar terms. For example, the terms "autonomic inflexibility", and "sympathetic inhibition" (p. 1118) were used to describe findings of increased electromyographic activity (EMG), lowered HR interbeat variablity and lowered skin conductivity (SC) gradients in GAD patients (Hoehn-Saric, McLeod, & Zimmerli, 1989). The most consistent finding in GAD autonomic symptomatology is reduced EMG variability (Hazlett, McLeod, & Hoehn-Saric, 1994), and increased EMG (Hoehn-Saric et al., 1989), which suggests that the observed reduced flexibility may be most applicable to striate muscles (Thayer, Friedman, & Borkovec, 1996).

Despite frequent reports of lower HR in GAD patients, GAD studies have often focused on sympathetic nervous system (SNS) influences without considering the possibility of differentiating parasympathetic nervous system (PNS) influences on HR (Hoehn-Saric & McLeod, 1988; Hoehn-Saric et al., 1989). Studies that have measured parasympathetic influences on HR found lowered respiratory sinus arrhythmia (RSA) (cardiac vagal tone) in GAD patients during aversive imagery and worry (Lyonfields, Borkovec, & Thayer, 1995), and in response to self-relevant worry (Thayer et al., 1996). Contradictory findings of increased RSA have also been reported in a series of studies using worriers versus non-worriers. Worriers demonstrated increased RSA, compared with non-worriers during self-relevant worry and non-stressful visuo-spatial and verbal tasks; and during relaxation, self-relevant worry and aversive imagery tasks worriers had significantly lower HR while no differences were found for RSA. The authors concluded that HR and RSA differences do not occur in worriers in response to stressful tasks or self-initiated worry (Davis, Montgomery, & Wilson, in press).

Respiratory-cardiac interactions and vagal activity. It is well established that cardic mechanisms are under dual sympathetic and parasympathetic neural control (Berntson, Cacioppo, & Quigley, 1993). RSA measures pure PNS tone (i.e., uncontaminated by SNS activity) - other responses are influenced by both SNS and PNS activity, or by SNS activity alone (Grossman, 1983). Since RSA is determined primarily by breathing frequency and pattern (Hirsch & Bishop, 1981) it is likely to be altered by emotions that affect these parameters (Porges, 1995). Typically, HR increases and RSA decreases in response to rapid, predominantly TH, low tidal-volume breathing (Grossman, 1983), and in response to unpleasant and/or threatening stimuli (Allen & Crowel, 1989, 1990; Grossman & Svebak, 1987; Lane, Adcock & Burnett, 1992). RSA is also typically absent during hyperventilation and returns with normal breathing (Cacioppo & Petty, 1982), whereas deep diaphragmatic breathing results in increased RSA (Fried, Fox, Carlton, & Rubin, 1984). In light of these considerations, the role of parasympathetic activity in GAD patients is unresolved and warrants further research.

The Physiology of Respiration

Normal respiration

Breathing involves inspiration and expiration cycles and depends on muscular and pressure mechanisms. During normal inspiration muscles act to increase the volume of the lungs located within the TH cavity. By contracting the intercostal muscles, located between the ribs, the ribcage is pulled upwards and outwards (TH breathing), whereas contraction of the diaphragm (costal and crural muscles), increases the TH cavity longitudinally which results in abdominal (ABD) breathing. Movement of air into the lungs can be achieved by breathing in either, TH or ABD modes, or both. During normal, quiet breathing ABD breathing predominates. Under more extreme respiratory demands, TH mode breathing predominates, where accessory muscles (sternocleidomastoids, scapular elevators and scaleni) lift the collarbones and scapulae allowing greater ribcage expansion (Kaufman & Schneiderman, 1986). Mead (1974) proposed that the diaphragm is the primary force generator of the respiratory system, whereas the intercostal and abdominal muscles function primarily as positioning muscles, which influences the geometry of the respiratory system. Elasticity, or compliance, of the lungs allows the lungs to stretch and contract in response to muscular and structural movements. Resistance refers to the opposition to the movement of the lungs. Pressure differences between internal alveolar pressure and external atmospheric pressure are utilised during inspiration, resulting in air being drawn inwards to equalise the pressure. Expiration reverses the process (Kaufman & Schneiderman, 1986). The normal rate of respiration for quiet breathing is about 12-14 breaths per minute, and approximatley 500ml of air enters the lungs with each breath (Comroe, 1974).

Function of respiration

The critical function of respiratory ventilation is to obtain oxygen (O_2) to fuel the body and to eliminate carbon dioxide (CO_2) produced by metabolism. Relative concentrations of these gases contribute to the acid-base balance of the blood (Comroe, 1974). Components of the airway passages (mouth, nose, trachea, bronchi and bronchioles) facilitate the movement of air into and out of the lungs. Alveoli within the bronchioles exchange gas into the bloodstream that delivers O_2 to body tissues and removes CO_2 as waste. Rate and depth of ventilation is determined by impulses originating in the medulla and pons. Concentrations of arterial O_2 pressure (PaO_2), arterial CO_2 pressure ($PaCO_2$) and pH are maintained at normal levels, except under heavy exercise, by chemoreceptor reflexes sensitive to blood gas concentration (Kaufman & Schneiderman, 1986). These mechanisms are also mediated by the autonomic nervous system and may be bypassed voluntarily by altering breathing parameters (Fried, 1993).

Alteration of ventilation by either overbreathing or underbreathing can lead to alterations in PaO_2 or $PaCO_2$ concentrations resulting in altered acid-base levels. When the body's acid-base balance is altered, homeostatic buffer mechanisms restore it, however if balance is unable to be restored, life threatening repercussions follow (Fried, 1993).

Parameters of investigation

Traditionally, analysis of the breathing cycle included measures of tidal volume (V_T) and respiratory rate (RR) with the limitation that underlying mechanisms were not analysed (Wientjes, 1992). Psychophysiological studies into respiration have investigated volume and timing parameters, gas exchange concentration measures, and quantitative measures that reflect the structure of the breathing cycle. The breathing cycle is also influenced by such parameters as inspiration/expiration ratio, TH/ABD ratio, and to a lesser degree pauses, sighs and irregularities in breathing (Boiten et al., 1994).

The effect of posture on respiration

Physiologists have devised methods of estimating the separate volume contributions of the thorax and abdomen to breathing calculated from changes in their respective diameters (Konno & Mead, 1967). Relative TH/ABD contributions have also been found to vary as a function of postural change. While in the upright position and during quiet breathing, TH breathing predominates, whereas in the supine position breathing tends to be ABD. When normal subjects altered their position from sitting to supine, the anterioposterior diameters of both TH and ABD decreased while their lateral diameters increased. Gravitational effects explained these changes on the abdomen during inspiration while upright and during expiration while supine (Vellody, Nassery, Druz, & Sharp, 1978). Muscle tension recordings have demonstrated that the upper intercostals were activated sooner than the diaphragm muscle during fast breathing, whereas during slow breathing the diaphragm tended to respond before the intercostals. The reason for the selection of intercostal muscles for fast manoeuvres is unclear (Sharp, Goldberg, Druz, & Danon, 1975).

Calibration for respiratory inductive plethysmography

Respiratory volume and timing components of the breathing cycle have been measured using a variety of techniques. These techniques may be categorised as being invasive (spirometry and pneumotachograph) or non-invasive (respiratory inductive plethysmography). Accompanying invasive techniques are the added disadvantages of added dead space and resistance through the use of facemasks, mouthpieces and tubes with valves (Sackner, Nixon, Davis, Atkins, & Sackner, 1980). Detailed descriptions of respiratory inductive plethysmography have been published relating the advantages of non-invasive respiratory measurement techniques. Important in the use of non-invasive techniques, are calibration procedures that allow the separate contributions of the TH and ABD relative to respiratory volume to be estimated (Watson, 1980; Gribbin, 1983; Chadha et al., 1982). Underlying current calibration procedures is a 2-degrees of freedom chest-movement model developed by Konno and Mead (1967). These researchers used isovolume manoeuvres, where the subject shifted respiratory volume between the TH and ABD compartments with the glottis closed. This model assumes that volume measured at the mouth is equal to the sum of the volume changes of the TH and ABD compartments. Because the isovolume manoeuvre is difficult to perform, calibration procedures that require minimum subject cooperation have been adopted for use with respiratory inductive plethysmography, based on the 2-degrees of freedom chest-movement model. Owing to individual variability in TH and ABD contributions, calibration procedures are necessary. Calibration involves two separate procedures for each participant. First, both transducer belt movements are scaled on the computer, second, a spirometer is used to calibrate the computer for respiratory volume prior to recording the participants respiratory volume. Multiple regression analysis is used to produce coefficients for volume and constant which are used with movement to predict V_T (Gribbin, 1983; Watson, 1980; Wientjes, 1992). These calibration procedures have been used during natural breathing in both normal and diseased patients (Tobin et al., 1983a, 1983b).

Effects of Changes to Respiration

The effects of involuntary autonomic control are evident in states such as anxiety. Anxiety is generally assumed to be adaptive when it prepares the individual to face or flee events which are viewed as threatening, but may be considered non-adaptive when present in the absence of threat or danger (Lehrer & Woolfolk, 1993).

Respiratory pattern of stress and anxiety

Literature reviews concerned with the effects of induced emotions on respiratory patterns indicate there are four basic breathing patterns (Wientjes, 1992, Boiten et al., 1994). Of these, rapid, shallow (TH) breathing with high inspiratory flow rate is of interest to the present study because it is associated with mental effort, tension, anxiety and fear. This breathing pattern is often accompanied by irregularities such as pauses and sighs. In contrast, rapid and deep breathing with high inspiratory flow rate is associated with excitement and arousal. Slow, shallow breathing, which is characterised by decreased respiratory drive, is associated with withdrawal and passivity and may accompany both unhappy or depressed moods and also happy, unexcited moods. Slow, deep breathing is widely associated with relaxed, resting states (Boiten et al., 1994; Wientjes, 1992). This respiratory pattern is widely documented in studies into relaxation (Lehrer & Woolfolk, 1993; Patel, 1991), active coping during threat (Cappo & Holmes, 1984), anxiety reduction (Clark et al., 1985; Clark & Hirschman, 1994), paced respiration (Montgomery, 1994), and respiratory retraining (Buckholtz, 1994). These respiratory patterns indicate that respiratory parameters, especially rate and mode contribution differences, underlie different psychological states.

Hyperventilation and anxiety symptoms

Alteration of ventilation by either overbreathing or underbreathing can lead to alterations in PaO_2 or $PaCO_2$ concentrations resulting in altered acid-base levels. Hyperventilation is a precise physiological term that is applied when respiratory clearance of CO_2 from the lungs reduces the optimal level of CO_2, which results in depletion of $PaCO_2$ (i.e., arterial hypocapnia) (Lum, 1975; Bass & Gardner, 1985b; Fried, 1987a). Hypocapnia produces symptoms by two mechanisms: i) decreased $PaCO_2$ causes respiratory alkalosis by decreasing acidity of the blood and ii) by reducing blood flow to the head, which decreases cerebral oxygen availability (i.e., cerebral hypoxia) (Timmins & Ley, 1994). Measurement of the percentage of end-tidal CO_2 ($PETCO_2$) has been used as a criterion for hyperventilation and is considered more accurate than symptom checklists (Fried, 1987a, 1993). "Graded hypoxia" has been proposed as the common factor underlying hyperventilation syndrome, panic disorder, anxiety, stress and psychosomatic disorders (Fried, 1993, p. 302). A similarity exists between the somatic symptoms of hypocapnia and those of anxiety (Huey & West, 1983; Grossman et al., 1985; Lum, 1981), and it is commonly assumed that these somatic symptoms are misinterpreted by the individual, thereby increasing anxiety (Clark, 1989). In clinical settings, the link between overbreathing and anxiety is demonstrated to patients by getting them to overbreathe in the TH mode. In this way patients experience the resulting anxiety symptoms. To counteract the effects of overbreathing patients are then instructed to walk up stairs which increases $PETCO_2$ concentration (Fried, 1987a, 1993; Timmons & Ley, 1994). Further evidence supporting the view that hypoxia underlies many conditions was found in a study where emotional arousal was induced in response to threat. Mild-hyperventilation (as measured by $PETCO_2$) was reported in 93% of normal subjects in either the pre- or task phases (Suess, Alexander, Smith, Sweeney, & Marion, 1980). In other studies hyperventilation has been linked with panic attacks (Clark et al., 1985), agoraphobia (Bonn et al., 1984), stress (Grossman, 1983), test-anxiety (Ley & Yelich, 1991), and emotional arousal (Thyer, Papsdorf, & Wright, 1984). While the apparent similarities between the symptoms of hyperventilation and those of anxiety are compelling, evidence supporting the link is by no means equivocal. For example, Bass and Gardner (1985b) found that even when profound hypocapnia was present, this did not impact on the physiological or psychological wellbeing of all patients. In two studies that used trait-anxious participants, the hyperventilation criterion was not met at rest (Tobin et al., 1983b), or in response to a mental stressor (Masaoka & Homma, 1997). An alternative view of symptom causes has also been presented (Watson & Pennebaker, 1989), which argues that increased awareness of bodily sensations and subsequent negative appraisal of these sensations explains why anxious individuals experience increased somatic complaints.

Respiration and clinical groups

Early studies investigating mental illness and respiratory patterns found that respiratory parameters such as respiratory mode differences, increased respiration rate (RR), irregular inspiratory/expiratory ratios, and increased minute volume (V_{MIN}) could be used to differentiate clinical groups (Christie, 1935; Clausen, 1951;

Finesinger, 1943; Skarbek, 1970; Stevenson & Ripley, 1952). Clausen (1951) reviewed a number of early investigations into respiratory patterns found in neurotic, psychotic and normal individuals to determine if mental illness modified respiratory patterns. Neurotic type patients demonstrated predominately TH breathing, increased RR, respiratory irregularities and prolonged inspiration and reduced expiration. In contrast, psychotic type patients demonstrated lower RR (catatonia), while low ABD amplitude, reduced V_T and higher incidence of regular breathing was observed in patients with schizophrenia. More recently, predominantly rapid, shallow breathing with intermittent periods of slow, deep breathing was observed in at rest chronic-anxiety patients (Tobin et al., 1983b).

Respiratory modes

The autonomic nervous system influences the respiratory modes. Lehrer and Woolfolk (1994) proposed that activation of the 'fight-flight' response results in increased muscle tension in the abdomen, lower back and perineum. When these areas are tense, TH mode breathing is required for inspiration, particularly as the diaphragm is less able to move against the tensed ABD below it.

The influence of induced emotion and arousal on TH and ABD modes of breathing has been investigated under a range of laboratory conditions. Landis (1926) found cumulative aversive stimulation (food and sleep deprivation, followed by severe electrical stimulation) resulted in increased TH breathing and decreased ABD breathing. During sustained mental tasks, which also involved threat of electric stimulation, TH circumference increased, whereas ABD movements did not change (Svebak, Dalen, & Storfjell, 1981). Faulkner (1941) found that pleasant imagined situations resulted in increased diaphragmatic movement, whereas unpleasant imagined situations decreased it. A similar psychophysiological differentiation of positive and negative affects was found while participants watched pleasant and unpleasant films in two experiments where TH/ABD movements, facial movements and self-report measures were used. ABD mode breathing resulted from viewing pleasant films whereas unpleasant films resulted in TH mode breathing (Ancoli, Kamiya, & Ekman, 1979; Ancoli & Kamiya, 1980). Gender differences were reported when increases in ABD circumference in response to comical films predicted increased laughter responses in women, but not in men, (Svebak, 1975). While these findings indicate that respiratory mode contributions vary along a pleasant-unpleasant dimension, some contrary evidence has been reported. Specifically, Mador and Tobin (1991) failed to alter the TH/ABD balance when noxious auditory stimuli and mental arithmetic were used. Similarly, TH to V_T ratios did not vary along a pleasant-unpleasant dimension as had been predicted from the above mentioned studies, when participants were exposed to a range of affective film stimuli, cold pressor and reaction time tasks (Boiten, 1998).

Respiratory modes and personality. Respiratory mode differences have been found to be related to personality or dispositional characteristics within normal subjects. In a series of studies investigating behavioural traits associated with differences in respiratory patterns (Haas, 1980; Haas, Axen, Ehrlichman, & Haas, 1980) the Eysenck Personality Inventory (Eysenck & Eysenck, 1964) and the Personality Research Form (Jackson, 1974) were administered to 160 male and female participants. Profile analysis was performed on slow-deep (diaphragmatic) and rapid-shallow (TH) breathers and on the highest and lowest CO_2 sensitivity groups. Contrasting influences in life orientations were found for the groups; slow-deep breathers were stable, capable, confident with a dislike for restrictions, whereas rapid-shallow breathers were found to be unstable, dependent, fearful and shy.

Associations between personality predispositions and respiratory mode contribution differences have also been investigated using reversal theory constructs (Apter, 1982). Svebak, Storfjell, and Dalen (1982) hypothesised that extreme groups formed from the telic/paratelic dominance pair of metamotivational states would differentiate psychophysiological measures. The results confirmed that telic dominant individuals demonstrated increased ABD amplitude and increased RR (TH amplitude was not measured) during threat of shock for poor performance. Also when performing a perceptual motor task the telic dominant group demonstrated increased TH amplitude (ABD amplitude was not measured) (Svebak & Murgatroyd, 1985). When TH and ABD measurements were taken, the telic dominant group demonstrated greater overall TH contribution under both threat and no-threat conditions. Under the threat condition the telic dominant group demonstrated increased RR and greater ABD contribution, than their paratelic counterparts (Svebak, 1986b). The finding of rapid (TH) and deep (ABD) breathing for the telic dominant group suggests that hyperventilation may be implicated.

Anxiety reduction

Breathing is the only vital biological function that is under both autonomic and considerable voluntary control. A reciprocal relationship exists where changes to respiration affects emotion, cognition and behaviour, and conversely, changes in emotion, cognition and behaviour produce changes in respiration (Ley, 1994). The reciprocal aspect of the relationship between breathing and arousal/emotion is demonstrated when voluntary respiratory changes serve to reduce them. Voluntary slowing of the respiratory cycle (McCaul, Solomon, & Holmes, 1979), and voluntary shorter inspiration with prolonged expiration (Cappo & Holmes, 1984), resulted in decreased emotional arousal in physical and psychological (self-report) measures with normal subjects under experimental conditions using threat. Anxiety reduction has also been demonstrated in clinical populations when voluntary slow paced respiration has been used. Slow paced respiration produced greater reductions in self-rated tension, state anxiety and skin conductance level (SCL) in high trait-anxiety alcohol-dependent subjects, but not in controls (Clark & Hirschman, 1994). Fried (1987b) found similar results in patients suffering various forms of anxiety (muscle tension, anxiety, panic disorder, and agoraphobia), as well as those suffering a wide range of medical disorders (cardiac arrhythmias, hypertension, migraine, irritable bowel syndrome, Raynaud's disease, chronic tiredness and hyperventilation). Fried made the important distinction that it is not just slowing the rate of respiration that is crucial, but that breathing more fully and deeply is required because this will automatically decrease breathing rate. These and other studies (Clark et al., 1985; Grossman et al., 1985; Salkovskis, Jones, & Clark, 1986) demonstrate that voluntary alteration of specific respiratory parameters, such as reduced respiratory rate and the use of ABD mode breathing, serve to reduce the somatic and psychological effects of anxiety.

Respiratory retraining

Kellerman (1985) suggests that when people reduce the intensity and depth of respiration it enables them to suppress the bodily feelings and sensations that accompany feeling, pain, stress and grief. Unfortunately, when respiratory patterns are altered to accommodate coping with these emotions, the respiratory patterns may become habitual (Buckholtz, 1994). Respiratory retraining has been used to address a wide range of problems that relate directly to respiration (asthma, chronic bronchitis, hyperventilation, shortness of breath and voice problems), as well as those that are indirectly related to respiration (sleep difficulties, circulatory problems, muscle tension, nervousness, digestion, skeletal structure, and during childbirth) (Fried, 1993).

While respiratory retraining often involves slowed respiration, ABD (or diaphragmatic) breathing is emphasised because it greatly improves mechanical efficiency in terms of muscle usage (Buckholtz, 1994), improves ventilation in the lower lobes (Hughes, 1979), and facilitates relaxation (Patel, 1991), as compared to TH breathing. An objective of respiratory retraining is to increase tidal volume by emphasising diaphragmatic breathing, while maintaining similar minute volume (Fried, 1993).

Respiratory physiologists and other rehabilitation therapists (i.e., nurses and physiotherapists), apply respiratory retraining techniques to patients suffering from a range of physical and psychological disorders (Fried, 1993; Timmons & Ley, 1994). Some clinical treatment studies have focused on respiratory retraining to modify and regulate the dysfunctional breathing patterns associated with somatic and psychological symptoms. For example, Grossman and associates (1985) used subjects that met hyperventilation syndrome criteria in a comparison study that used a slow, regular breathing pattern and a partial-treatment pattern. Respiratory retraining altered psychological, situational and dispositional characteristics and reduced the frequency and range of psychosomatic complaints over a ten-week period. Support for the long-term effects of respiratory retraining was reported following a six-year follow-up of a treatment study that compared respiratory retraining, isometric relaxation and cognitive modification with agoraphobia sufferers. The greatest long-term treatment benefits were found for respiratory retraining (Franklin, 1989).

Reversal Theory

Reversal theory (Apter, 1982) is increasingly being used to explain a wide range of states and behaviours, including stress, anxiety and arousal based psychopathology. The theory provides a framework to explain the phenomenon of subjective experience as it relates to motivation, emotion, and personality. An underlying assumption of the theory is that conscious experience has structure. This structure derives from motivational variables (metamotivational modes) that give rise to different emotions or feelings that are experienced at different levels of positive and negative hedonic tone.

Apter (1989) proposed eight different metamotivational modes that operate as four pairs of opposite modes. As one variable from each pair will be active at any given time, four metamotivational modes will be operating at all times. Aside from each metamotivational mode having an opposite, each of the eight metamotivational modes gives rise to two opposite emotional/feeling states, which leads to an account of sixteen emotions. Of the emotions accounted for by reversal theory, two distinct types of emotion have been proposed: somatic and transactional emotions. Somatic emotions are moderated by felt physiological arousal while transactional emotions reflect felt gain or loss in response to transactions with people, situations or objects. This review will focus on the somatic emotions as the interpretation of 'felt-arousal' is of interest to the present study.

Telic and paratelic modes

The first pair of somatic emotions stem from the arousal-avoiding and arousal-seeking metamotivational modes and are referred to respectively, as the telic and paratelic modes. The telic mode is serious-minded and pleasure is derived from goal achievement. In contrast, the paratelic mode is less concerned with goals, but rather with immediate sensation and behaviour, where pleasure is derived from the activity itself. Most research has concerned itself with the telic/paratelic pair of metamotivational modes, and reversal theorists assume that frequent reversal between these two modes is desireable and healthy (Lachenicht, 1988). The second pair of somatic emotions is the conformist and negativistic modes. The conformist mode is experienced as a willingness to conform or please, in relation to external pressure, whereas the negativistic mode is characterised by rebelliousness and non-conformity to external pressures and expectations (Apter, 1989).

Telic/paratelic and conformist/negativistic modes combine to produce pairs of opposite somatic emotions. When a person is in the telic-conformist combination at low levels of arousal the experience is relaxing and pleasant, whereas high arousal is experienced as anxiety that is unpleasant. Because high arousal is unpleasant in telic states, the term arousal-avoiding is applied. Alternately, when a person is in the paratelic-conformist combination high arousal is experienced as excitement that is pleasant, hence the term arousal-seeking, whereas low arousal is experienced as boredom that is unpleasant. In the telic-negativistic combination people experience low arousal as placidity that is pleasant, whereas high arousal is experienced as anger that is unpleasant. In the paratelic-negativistic mode combination low arousal is experienced as sullenness that is unpleasant, and high arousal is experienced as provocativeness where pleasure is derived from opposing some external influence (Apter, 1988).

Changes between modes are known as reversals. Reversals occur in response to internal and external contingencies, frustration with the present state, and with satiation, where the passage of time eventually produces a reversal. For example, if a person in the telic-conformist combination is anxious they will want to alter their experience from being unpleasant to pleasant. This can be achieved by either reducing their arousal to a more pleasant level (relaxation), or alternatively they can reverse into the paratelic-conformist mode and experience excitement which shares the same level of arousal as anxiety, but differs in the interpretation of felt arousal. (Apter, 1989).

Dominance

Reversal theory proposes that some individuals have a strong bias towards particular metamotivational modes, known as mode dominance. These individuals spend more time in their preferred mode than 'balanced' individuals who readily reverse between modes. For example, a telic dominant individual will prefer to spend most of their time in a state of low arousal, whereas paratelic dominant individuals prefer to spend more time in a state of high arousal (Apter, 1989). Reversal theory holds that when reversal between modes is inhibited, or when reversal occurs inappropriately, the risk of experiencing psychological problems is increased and this can lead to psychopathology (Apter, 1982).

Telic dominance and trait-anxiety. Several studies have observed similarities between extreme telic dominance and the characteristics of high trait-anxiety. Telic dominant individuals regarded daily bothersome events as threatening in one study (Baker, 1988), while another found that telic dominant people were threatened even by low levels of stress. Paratelic individuals, in contrast, enjoyed relatively high stress levels and reacted negatively to low levels of arousal (Martin, Kuiper, Olinger, & Dobbin, 1987). Individuals high in telic dominance and arousability have also demonstrated significant levels of trait-anxiety (Lafreniere, Gillies, Cowles, & Toner, 1993). Telic dominance, perceived threat, and negative hedonic tone were found to interact with decreased $PETCO_2$, which indicates a link between telic dominance and hyperventilation (Svebak & Grossman, 1985). The association between telic dominance and trait-anxiety is particularly important to the present investigation, because the characteristics of extreme telic dominance provides valuable additional information that may be applicable to trait-anxiety. In this light, the previously mentioned findings that extreme telic dominant individuals demonstrate distinct respiratory mode contribution differences (Svebak, Storfjell, & Dalen, 1982; Svebak & Murgatroyd, 1985; Svebak, 1986), may hold true for trait-anxious individuals as well.

Tension and effort-stress

Apter (1989) argued for a re-conceptualisation of stress to explain different types of stress, including stress associated with work and effort. Tension-stress has been defined as the discomfort that arises when there is a "discrepancy between the preferred and actual levels of some variable like felt arousal", whereas effort-stress has been defined as "the experience of expending effort in order to avoid or reduce tension-stress" (p. 171). In this context, effort is made to solve, cope with, or improve situations that cause discomfort. A person in a telic state of high arousal will experience tension-stress because they prefer low arousal in that state. Alternately, in a paratelic state of low arousal they will experience tension-stress because in that state high arousal is preferable. When the preferred and actual states match the person is at ease with the pleasurable emotion that is experienced. If the effort that is made is appropriate, and made at the right time, a reduction in tension-stress may result (Apter, 1989). Several studies have reported that telic-dominant individuals are more likely to use effortful problem-solving strategies to decrease tension-stress than are their paratelic counterparts (Baker, 1988; Howard, 1988; Murgatroyd, 1985). The relationship between telic/paratelic dominance and tension and effort-stress has been demonstrated experimentally where telic dominance predicted higher academic performance effort (Svebak, 1997), and in workplace studies where tension-stress was found to be related to neck and shoulder pain, and effort-stress was related to lower back pain (Svebak, Mykletun, & Bru, 1997).

Tension-stress that is experienced in the Conformist/Negativist modes is stressful and gives rise to the negative somatic emotions: anxiety, boredom, anger, and sullenness. To facilitate testing and operationalising reversal theory constructs various measurement methodologies have been developed. These include instruments such as the Tension and Effort Stress Inventory (TESI) (Svebak, 1993), which measures somatic and transactional emotions and the Metamotivational Style Profile (MSP) (Apter, Mallows, & Williams, 1998), which measures metamotivational mode dominance, mode salience and motivational style.

Personality predispositions have been found to either facilitate or inhibit the experience of tension-stress. The predisposition towards high or low arousability was found to be influential, such that, in telic dominant persons the tendency towards high arousability results in more frequent tension-stress (unpleasant anxiety) than in a person with low arousability (Lafreniere et al., 1993). A poor fit between arousal preferences and arousability will increase stress and may lead to psychopathology (Apter, 1982). Chronic anxiety for example, could develop as a result of telic dominance (arousal-avoidance), occurring when a person frequently experiences high levels of arousal, yet is unable to reverse into their preferred low arousal state. This process is referred to as "inhibited reversal" (Apter, 1989, p. 143). Support for this proposition is found in studies where telic dominant individuals breathed more rapidly and more deeply than their paratelic counterparts during stress conditions (Svebak et al., 1982; Svebak & Murgatroyd, 1985; Svebak, 1986). This implies that telic dominance is likely to be associated with the experience of psychosomatic symptoms.

Conclusion

Literature from several areas of research inquiry were reviewed with the aim of identifying areas of possible future GAD research. The influence of PNS activity on HR is unresolved in GAD research. Consequently, because RSA typically decreases in response to rapid, predominantly TH, low V_T breathing and in response to unpleasant or threatening stimuli, its use in GAD research may be of value by identifying parasympathetic (vagal) changes.

Research findings from clinical groups and from studies that demonstrate the role of respiratory dysfunction in the aetiology of panic disorder and agoraphobia, and the functional physiology of respiration were reviewed. In addition, the importance of calibration procedures associated with respiratory inductive plethysmography for measuring respiratory mode excursions relative to volume changes was outlined.

Empirical evidence from several domains of inquiry indicate that TH mode breathing may be implicated in GAD. Firstly, certain dysfunctional breathing patterns may be associated with the experience of stress and anxiety. Respiratory mode contribution differences have also been shown to be linked with personality predispositions. Specifically, rapid, shallow (TH) breathing may be associated with trait-anxiety. Secondly, anxiety reduction research and evidence from the field of respiratory retraining demonstrate that slow, ABD mode breathing is used to counteract the effects of anxiety and the symptoms of hyperventilation. Inversely, this supports the view that rapid, TH mode breathing may underlie anxiety and hyperventilation.

Reversal theory is increasingly being used as a conceptual framework to explain the dynamics of emotion, stress and anxiety related behaviour. Two important motivational variables are the telic and paratelic modes which reflect opposing ways of experiencing felt-arousal (arousal-avoiding/-seeking). Since it is considered healthy to reverse between the telic and paratelic modes, it has been proposed that telic dominant individuals may develop chronic anxiety when reversal to their preferred state of low arousal is inhibited (Apter, 1989). Empirical evidence indicates that telic dominance and trait-anxiety are closely related. Consequently, the finding that telic dominant individuals demonstrate respiratory mode contribution differences supports the proposal that TH mode breathing may be implicated in trait-anxiety.

References

Allen, M. T., & Crowel, M. D. (1989). Patterns of autonomic response during laboratory stressors. *Psychophysiology, 26*, 603-614.

Allen, M. T., & Crowel, M. D. (1990). The effects of paced respiration on cardiopulmonary responses to laboratory stressors. *Journal of Psychophysiology, 4*, 357-368.

American Psychiatric Association (1987). *Diagnostic and Statistical Manual of Mental Disorders* (3rd ed.). Washington, DC: Author.

American Psychiatric Association (1994). *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.). Washington, DC: Author.

Ancoli, S., & Kamiya, J. (1980). Respiratory patterns during emotional expression. *Biofeedback and Self-Regulation, 5,* 356.

Ancoli, S., Kamiya, J., & Ekman, P. (1979). Psychophysiological differentiation of positive and negative affects. *Biofeedback and Self-Regulation, 4,* 242.

Apter, M. J. (1982). *The experience of motivation: The theory of psychological reversals*. London: Academic Press.

Apter, M. J. (1988). Reversal theory as a theory of the emotions. In M. J. Apter, & M. Cowles (Eds.), *Progress in reversal theory* (pp. 43-62). Amsterdam: North Holland.

Apter, M. J. (1989). *Reversal theory: Motivation, emotion and personality*. London: Routledge.

Apter, M. J., Mallows, R., & Williams, S. (1998). The development of the Motivational Style Profile. *Personality & Individual Differences, 24*, 7-18.

Baker, J. (1988). Stress appraisals and coping in everyday life. In M. J. Apter, J. H. Kerr, & M. Cowles (Eds.), *Progress in reversal theory* (pp. 117-128). Amsterdam: North Holland.

Bass, C., & Gardner, W. N. (1985a). Diagnostic issues in the hyperventilation syndrome. *British Journal of Psychiatry, 146*, 101-102.

Bass, C., & Gardner, W. N. (1985b). Respiratory and psychiatric abnormalities in chronic symptomatic hyperventilation. *British Medical Journal, 290*, 1387-1390.

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Respiratory sinus arrhythmia: Autonomic origins, physiological mechanisms, and psychophysiological implications. *Psychophysiology, 30*, 183-196.

Boiten, F. A. (1998). The effects of emotional behaviour on components of the respiratory cycle. *Biological Psychology, 49*, 29-51.

Boiten, F. A., Fridja, N. H., & Wientjes, C. J. E. (1994). Emotions and respiratory patterns: Review and critical analysis. *International Journal of Psychophysiology, 17*, 103-128.

Borkovec, T. D., & Hu, S. (1990). The effect of worry on cardiovascular response to phobic imagery. *Behaviour Research and Therapy, 28*, 69-73.

Borkovec, T. D., & Inz, J. (1990). The nature of worry in generalised anxiety disorder: A predominance of thought activity. *Behaviour Research and Therapy, 28*, 153-158.

Bonn, J. A., Redhead, C. P. A., & Timmons, B. H. (1984). Enhanced adaptive behavioural response in agoraphobic patients pretreated with breathing retraining. *The Lancet, 2*, 665-669.

Brown, T. A., O'Leary, T. A., & Barlow, D. H. (1993). Cognitive-behavioural treatment of generalised anxiety disorder. In D. H. Barlow (Ed.), *Clinical handbook of psychological disorders* (pp. 137-188) (2nd Ed.). New York: Guilford Publications.

Buckholtz, I. (1994). Breathing, voice, and movement therapy: Applications to breathing disorders. *Biofeedback and Self-Regulation, 19,* 141-153.

Cacioppo, J. T., & Petty, R. E. (1982). *Perspectives in cardiovascular psychophysiology.* New York: Guilford Press.

Cappo, B. M., & Holmes, D. S. (1984). The utility of prolonged respiratory exhalation for reducing physiological and psychological arousal in non-threatening and threatening situations. *Journal of Psychosomatic Research, 28,* 265-273.

Chadha, T. S., Watson, H., Birch, S., Jenouri, G. A., Schneider, A. W., Cohn, M. A., & Sackner, M. A. (1982). Validation of respiratory inductive plethysmography using different calibration procedures. *American Review of Respiratory Disorders, 125,* 644-649.

Christie, R. V. (1935). Some types of respiration in the neuroses. *Quarterly Journal of Medicine, 4,* 427-432.

Clark D. M. (1989). Anxiety states: Panic and generalized anxiety. In K. Hawthorn, P. Salkovskis, J. Kirk, & D. M. Clark (Eds.), *Cognitive behavior therapy for psychiatric problems: A practical guide* (pp.52-96). Oxford, U K: Oxford University Press.

Clark, M. E., & Hirschman, R. (1994). Effects of paced respiration on anxiety reduction in a clinical population. *Biofeedback and Self-Regulation, 19,* 273-284.

Clark, D. M., Salkovskis, P. M., & Chalkley, A. J. (1985). Respiratory control as a treatment for panic attacks. *Journal of Behavioral Therapy & Experimental Psychiatry, 16,* 23-30.

Clausen, J. (1951). Respiration movement in normal, neurotic and psychotic subjects. *Acta Psychiatrica Et Neurologia, 68,* 1-74.

Comroe, J. H. (1974). *The physiology of respiration* (2nd ed.). Chicago: Year Book Medical Publications.

Davis, M., Montgomery, I. M., & Wilson, G. V. (in press). Worry and heart rate variables relationships under challenge.

Eysenck, H. J., & Eysenck, S. B. G. (1964). *Eysenck personality inventory: Manual.* United Kingdom: University of London Press.

Faulkner, W. B. (1941). Effects of the emotions on diaphragmatic function. *Psychosomatic medicine, 3,*187-189.

Finesinger, J. E. (1943). The spirogram in certain psychiatric disorders. *American Journal of Psychiatry, 100*, 159-169.

Foa, E. B., & Kozac, M. J. (1986). Emotional processing and fear: Exposure to corrective information. *Psychological Bulletin, 99*, 20-35.

Franklin, J. A. (1989). A 6-year follow-up of the effectiveness of respiratory retraining, in-situ isometric relaxation, and cognitive modification in the treatment of agoraphobia. *Behaviour Modification*, *13*, 139-167.

Fried, R. (1987a). *The hyperventilation syndrome - Research and clinical treatment.* Baltimore: John Hopkins University Press.

Fried, R. (1987b). Relaxation and biofeedback-assisted imagery: The importance of breathing rate as an index of hypoarousal. *Biofeedback and Self-Regulation*, *12*, 273-279.

Fried, R. (1993). The role of respiration in stress and stress control: Towards a theory of stress as a hypoxic phenomenon. In P. M. Lehrer, & R. L. Woolfolk (Eds.), *Principles and practice of stress management* (pp. 301-331). New York: Guilford Press.

Fried, R., Fox, M. G., Carlton, R. M., & Rubin, S. R. (1984). Method and protocols for assessing hyperventilation and its treatment. *Journal for Drug Research and Therapy*, *9*, 280-288.

Gribbin, H. R. (1983). Using body surface movements to study breathing. *Journal of Medical Engineering & Technology*, *5*, 217-223.

Grossman, P. (1983). Respiration, stress, and cardiovascular function. *Psychophysiology*, *20*, 284-300.

Grossman, P., DeSwart, J. C. G., & Defares, P. B. (1985). A controlled study of a breathing therapy treatment of hyperventilation syndrome. *Journal of Psychosomatic Research Abstract*, *29*: 97.

Grossman, P., & Svebak, S. (1987). Respiratory sinus arrhythmia as an index of parasympathetic cardiac control during active coping. *Psychophysiology*, *24*, 28-235.

Grossman, P., & Wientjes, C. J. E. (1989). Respiratory disorders: Asthma and hyperventilation syndrome. In G. Turpin (Ed.), *Handbook of Clinical Psychophysiology* (pp. 519-554). Chichester: Wiley

Haas, S. S. (1980). Relationships between individual differences in personality and respiratory behavior: An exploratory study. *Dissertation Abstracts International*, *41*, 1483-B.

Haas, S. S., Axen, H., Ehlichman, H. E., & Haas, F. (1980). Relationships between personality characteristics and respiratory behavior. *The Physiologist*, *23*, 74.

Hazlett, R. 1., McLeod, D. R., & Hoehn-Saric, R. (1994). Muscle tension in generalised anxiety disorder: Elevated muscle tonus or agitated movement. *Psychophysiology*, *31*, 189-195.

Hirsch, J. A., & Bishop, B. (1981). Respiratory sinus arrhythmia in humans: How breathing patterns modulate heart rate. *American Journal of Physiology, 241*, H620-H629.

Hoehn-Saric, R., & McLeod, D. R. (1988). The peripheral nervous system: Its role in normal and pathological anxiety. *Psychiatric Clinics of North America, 11*, 375-395.

Hoehn-Saric, R., McLeod, D. R., & Zimmerli, W. D. (1989). Somatic manifestations in women with generalized anxiety disorder. *Archives of General Psychiatry,* 46, 1113-1119.

Howard, R. (1988). Telic dominance, personality and coping. In M. J. Apter, & M. Cowles (Eds.). *Progress in reversal theory* (pp. 129-141). Amsterdam: North Holland.

Huey, S. R., & West, S. G. (1983). Hyperventilation: Its relation to symptom experience and to anxiety. *Journal of Abnormal Psychology, 92,* 422-432.

Hughes, R. L. (1979). Does abdominal breathing affect regional gas exchange? *Chest, 76*, 288-293.

Jackson, D. N. (1974). *The personality research form: Manual.* New York: Research Psychologists Press

Kaufman, M. P., & Schneiderman, N. (1986). Physiological bases of respiratory physiology. In M. G. H. Coles, E. Donchin, & S. W. Porges (Eds.), *Psychophysiology: Systems, processes, and applications* (pp. 107-121). New York: Guilford Press.

Kellerman, S. (1985). *Emotional anatomy: The structure of experience*. Berkeley, US: Center Press.

Konno, K., & Mead, J. (1967). Measurement of the separate volume changes of rib cage and abdomen during breathing. *Journal of Applied Physiology, 22*, 407-422.

Lachenicht, L. (1988). A critical introduction to reversal theory. In M. J. Apter, J. H. Kerr, & M. Cowles (Eds.), *Progress in reversal theory* (pp. 1-42). Amsterdam: North Holland.

Lafreniere, K. D., Gillies, L. A., Cowles, M. P., & Toner, B. B. (1993). Arousability and telic dominance. In J. H. Kerr, S. Murgatroyd, & M. J. Apter (Eds.), *Advances in reversal theory* (pp. 257-266). Amsterdam: Swets & Zeitlinger.

Landis, C. (1926). Studies of emotional reactions. V. Severe emotional upset. *Journal of Comparative Psychology, 6*, 221-242.

Lane, J. D., Adcock, A., & Burnett, R. E. (1992). Respiratory sinus arrhythmia and cardiovascular responses to stress. *Psychophysiology, 29*, 461-470.

Lehrer, P. M., & Woolfolk, R. L. (1993). *Principles and practice of stress management* (2nd ed.). New York: Guilford Press.

Lehrer, P. M., & Woolfolk, R. L. (1994). Respiratory system involvement in western relaxation and self-regulation. In B. H. Timmins, & R. Ley (Eds.), *Behavioral and psychological approaches to breathing disorders* (pp. 191-200). New York: Plenum Press.

Ley, R. (1994). Breathing and the psychology of emotion, cognition, and behaviour. In B. H. Timmins, & R. Ley (Eds.), *Behavioral and psychological approaches to breathing disorders* (pp. 81-91). New York: Plenum Press.

Ley, R., & Yelich, G. (1998). Fractional end-tidal CO_2 as an index of the effects of stress on math performance and verbal memory of test-anxious adolescents. *Biological Psychology, 49*, 83-94.

Lum, L.C. (1975). Hyperventilation: The tip of the iceberg. *Journal of Psychosomatic Research, 19*, 375-383.

Lum, L.C. (1981). Hyperventilation and the anxiety state. *Journal of the Royal Society of Medicine*, *74*, 1-4.

Lyonfields, J. D., Borkovec, T. D., & Thayer, J. F. (1995). Vagal tone in generalized anxiety disorder and the effects of aversive imagery and worrisome thinking. *Behaviour Therapy*, *26*, 457-466.

Mador, M. J., & Tobin, M. J. (1991). Effect of alterations in mental activity on the breathing pattern in healthy subjects. *American Review of Respiratory Disorders*, *144*, 481-487.

Martin, R. A., Kuiper, N. A., Olinger, L. J., & Dobbin, J. (1987). Is stress always bad? Telic verses paratelic dominance as a stress moderating variable. *Journal of Personality and Social Psychology*, *53*, 970-982.

Masaoka, Y., & Homma, I. (1997). Anxiety and respiratory patterns: Their relationship during mental stress and physical load. *International Journal of Psychophysiology, 27*, 153-159.

McCaul, K. D., Soloman, S., & Holmes, D.S. (1979). Effects of paced respiration and expectations on physiological and psychological responses to threat. *Journal of Personality and Social Psychology*, *37,* 564-571.

Mead, J. (1974). Mechanics of the chest wall. In L. D. Pergally, A. S. Rebuck, & E. J. M. Campbell (Eds.), *Loaded breathing* (pp. 35-49). Edinburgh: Churchill-Livingstone.

Montgomery, G. T. (1994). Slowed respiration training. *Biofeedback and Self-Regulation, 19*, 211-225.

Murgatroyd, S. (1985). The nature of telic dominance. In M. J. Apter, D. Fontana, & S. Murgatroyd (Eds.), *Reversal theory: Applications and developments* (pp. 1-19). Cardiff: University College Cardiff Press.

Nathan, P. E., & Gorman, J. M (1998). *A guide to treatments that work.* New York: Oxford University Press.

Patel, C. (1991). *The complete guide to stress management.* New York: Plenum Press.

Porges, S. W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. A polyvagal theory. *Psychophysiology, 32*, 301-318.

Rapee, R. S. (1991). Generalized anxiety disorder: A review of clinical features and theoretical concepts. *Clinical Psychology Review, 11*, 419-440.

Sackner, J. D., Nixon, A. J., Davis, B., Atkins, N., & Sackner, M. A. (1980). Effects of breathing through external dead space on ventilation at rest and during exercise. *American Review of Respiratory Disease, 122*, 933-940.

Salkovskis, P. M., Jones, D. R. O., & Clark, D. M. (1986). Respiratory control in the treatment of panic attacks: Replication and extension with concurrent measurement of behaviour and pCO_2. *British Journal of Psychiatry, 148*, 526-532.

Seuss, W. M., Alexander, A. B., Smith, D. D., Sweeney, H. W., & Marion, R. J. (1980). The effects of psychological stress on respiration: A preliminary study of anxiety and hyperventilation. *Psychophysiology, 17,* 535-540.

Sharp, J. T., Goldberg, N. B., Druz, W. S., & Danon, J. (1975). Relative contributions of the ribcage and abdomen to breathing in normal subjects. *Journal of Applied Physiology, 39*, 608-618.

Skarbek, A. (1970). A psychophysiological study of breathing behaviour. *British Journal of Psychiatry*, *116*, 637-641.

Spielberger, C. D. (1983). *State-trait anxiety inventory (STAIS-AD Manual).* California: Mind Garden Inc.

Stevenson, I., & Ripley, H. S. (1952). Variations in respiration and in respiratory symptoms during changes in emotion. *Psychosomatic Medicine, 14*, 476-490.

Svebak, S. (1975). Respiratory patterns as predictors of laughter. *Psychophysiology, 12*, 62-65.

Svebak, S. (1986). Patterns of cardiovascular-somatic-respiratory interactions in the continuous perceptual-motor task paradigm. In P. Grossman, K. Janssen, & D. Vaitl (Eds.), *Cardiorespiratory and cardiosomatic psychophysiology* (pp. 219-230). New York: Plenum Press.

Svebak, S. (1993). The development of the tension and effort-stress inventory (TESI). In J. H. Kerr, S. Murgatroyd, & M. J. Apter (Eds.), *Advances in reversal theory* (pp. 189-204). Amsterdam: Swets Zeitlander.

Svebak, S. (1997). Tension- and effort-stress as predictors of academic performance. In M. J. Apter, & S. Svebak (Eds.), *Stress and health: A reversal theory perspective* (pp. 45-55). Washington DC: Taylor & Francis.

Svebak, S., Dalen, K., & Storfjell, O. (1981). The psychological significance of task-induced tonic changes in somatic and autonomic activity. *Psychophysiology, 18,* 403-409.

Svebak, S., & Grossman, P. (1985). The experience of psychosomatic symptoms in the hyperventilation provocation test and in non-hyperventilation tasks. *Scandinavian Journal of Psychophysiology, 26*, 327-335.

Svebak, S., Storfjell, O., & Dalen, K. (1982). The effect of a threatening context upon motivation and task-induced physiological changes. *British Journal of Psychology, 73*, 505-512.

Svebak, S., & Murgatroyd, S. (1985). Metamotivational dominance: A multimethod validation of reversal theory constructs. *Journal of Personality and Social Psychology, 48*, 107-116.

Svebak, S., Mykletyn, R., & Bru, E. (1997). In M. J. Apter, & S. Svebak (Eds.), *Stress and health: A reversal theory perspective* (pp. 57-66). Washington DC: Taylor & Francis.

Thayer, J. F., Friedman, B. H., & Borkovec, T. D. (1996). Autonomic characteristics of generalized anxiety disorder and worry. *Biological Psychiatry, 39*, 255-266.

Thyer, B., Papsdorf, J., & Wright, P. (1984). Physiological effects of acute intentional hyperventilation. *Behaviour Research and Therapy, 22*, 587-590.

Timmins, B. H., & Ley, R. (1994). *Behavioral and psychological approaches to breathing disorders*. New York: Plenum Press.

Tobin, M. J., Chadha, T. S., Jenouri, G., Birch, S. J., Hacik, B., Gazeroglu, H. B., & Sackner, M. A. (1983 a). Breathing patterns 1: Normal subjects. *Chest, 84*: 202-205.

Tobin, M. J., Chadha, T. S., Jenouri, G., Birch, S. J., Hacik, B., Gazeroglu, H. B., & Sackner, M. A. (1983 b). Breathing patterns 2: Diseased patients. *Chest, 84*: 286-294.

Vellody, V. P., Nassery, M., Druz, W. S., & Sharp, J. T. (1978). Effects of body position change on thoracoàbdominal motion. *Journal of Applied Physiology, 45*, 581-589.

Watson, H. (1980). The technology of respiratory inductive plethysmography. In F. D. Scott, B. Raftery, & I. Goulding (Eds.), *ISAM 1979: Proceedings of the Third International Symposium on Ambulatory Monitoring* (pp. 537-558). London: Academic Press.

Watson, D., & Pennebaker, J. W. (1989). Health complaints, stress and distress: Exploring the central role of negative affectivity. *Psychological Review, 98*, 234-254.

Wientjes, C. J. E. (1992). Respiration in psychophysiology: Methods and applications. *Biological Psychology*, *34*, 179-203.

Empirical Study

The Influence of Affect on the Respiratory, Autonomic and Emotional Responses of High and Low Trait-Anxiety Individuals

Abstract

To assess the propositions that trait-anxiety is associated with thoracic (TH), rather than abdominal (ABD) mode breathing, and that unpleasant stimuli produces greater stress in trait-anxious participants, high (n = 19) and low (n = 20) anxiety groups were presented with blocks of pleasant, neutral, and unpleasant affective picture stimuli. Self-report and psychophysiological measures assessed physical and somatic emotion responses to stimuli following each block of picture trials. As predicted, the high anxiety group demonstrated significantly greater TH breathing, compared with low anxiety controls. In contrast, the low anxiety group demonstrated decreased TH breathing during neutral and unpleasant conditions compared with the pleasant condition. Respiratory sinus arrhythmia and other autonomic measures failed to differentiate groups as predicted across affective conditions. On the other hand, psychological self-report ratings confirmed the prediction that trait-anxious individuals would demonstrate greater tension-stress compared with controls. This was evident as significantly increased negative somatic emotion responses (anxiety, anger and sullenness), and a significantly decreased positive somatic emotion response (relaxation) for the trait-anxious group. Stress, arousal and hedonic tone ratings differentiated the pleasant and unpleasant conditions, but not the neutral and pleasant conditions, and the high anxiety group was more stressed, and had lower hedonic tone than controls. Overall, the psychological indices were more consistent and sensitive to differences between groups and affect conditions than the physiological response measures. Treatment applications of the physiological and psychological results were discussed.

Generalised anxiety disorder (GAD) is characterised by excessive and uncontrollable worry, and is accompanied by such prominent somatic symptomatology as; muscle tension, easy startle and hypervigilence (see Diagnostic and Statistical Manual of Mental Disorders (4th ed.), abbreviated as DSM-IV, American Psychiatric Association, 1994). GAD is often a life-long, characterological trait and is consistently associated with many other anxiety disorders (Nathan & Gorman, 1998). According to Rapee (1991), trait-anxiety becomes a disorder when it interferes with the individual's functioning. Compared with other anxiety disorders, and despite its high prevalence, GAD is one of the least studied anxiety disorders (Nathan & Gorman, 1998). Owing to its chronic nature, its treatment is often met with only meagre gains (Brown, O'Leary, & Barlow, 1993), consequently research that increases the understanding of the nature, maintenance and reduction of GAD is likely to lead to treatment gains that may be applied to other anxiety disorders.

GAD and autonomic responses

Prior to its revision in 1994, the DSM-III R (APA, 1987, p. 253) listed "autonomic hyperactivity" as a GAD symptom criterion. Autonomic responses, particularly heart rate (HR), have frequently been reported to be at odds with this criterion when responses were not higher in GAD sufferers compared with controls. Borkovec and Hu (1990) found decreased HR responses to phobic image exposure in GAD patients and concluded that GAD sufferers were "autonomic restrictors"(p. 72). Other researchers have described GAD patients' autonomic responses in similar terms. For example, to describe findings of increased electromyograph (EMG), lowered HR interbeat variablity and lowered SC gradients in GAD patients, the terms "autonomic inflexibility", and "sympathetic inhibition" (p. 1118) were used (Hoehn-Saric, McLeod, & Zimmerli, 1989). The most consistent finding in GAD autonomic symptomatology is reduced EMG variability (Hazlett, McLeod, & Hoehn-Saric, 1994), and increased EMG (Hoehn-Saric et al., 1989). Thayer, Friedman and Borkovec (1996) indicated that the observed reduced flexibility may be most applicable to striate muscles.

Few GAD studies have attempted to differentiate sympathetic and parasympathetic nervous system influences on HR (Hoehn-Saric & McLeod, 1988; Hoehn-Saric et al., 1989), despite the well established finding that cardic mechanisms are under dual sympathetic and parasympathetic neural control (Berntson, Cacioppo, & Quigley, 1993). Respiratory sinus arrhythmia (RSA) is the only physiological index that measures 'pure' parasympathetic nervous system tone, whereas all the other responses are influenced by both parasympathetic and sympathetic activity, or by sympathetic activity alone (Grossman, 1983). Studies that have measured parasympathetic activity of GAD patients, found lowered cardiac vagal-tone during aversive imagery and worry (Lyonfields, Borkovec, & Thayer, 1995), and in response to self-relevant worry (Thayer et al., 1996). Contradictory findings of increased vagal-tone have also been reported in a series of studies using worriers versus non-worriers. Worriers demonstrated increased HR variability compared with non-worriers during self-relevant worry and non-stressful visuo-spatial and verbal tasks; and during relaxation, self-relevant worry and aversive imagery tasks worriers had significantly lower HR while no differences were found for vagal-tone as measured by RSA. The authors concluded that HR and RSA differences do not occur in worriers in response to stressful tasks or self-initiated worry (Davis, Montgomery, & Wilson, in press). The discrepancy in RSA findings between these studies could be attributed to sample differences between clinical GAD patients and non-clinical worriers.

Since RSA is determined primarily by breathing frequency and pattern (Hirsch & Bishop, 1981) it is likely to be altered by emotions which affect these parameters (Porges, 1995). Typically, HR increases and RSA decreases in response to rapid, predominantly TH, low volume breathing (Grossman, 1983), and in response to unpleasant and/or threatening stimuli (Allen & Crowel, 1989, 1990; Grossman & Svebak, 1987; Lane, Adcock & Burnett, 1992). RSA is also typically absent during hyperventilation and returns with normal breathing (Cacioppo & Petty, 1982). In light of these findings RSA is an important measure for investigating the relationship between trait-anxiety and respiration.

Respiration and anxiety

Anxiety and hyperventilation. A number of anxiety disorders have been linked with respiratory dysfunction. Alteration of ventilation by either overbreathing or underbreathing can lead to alterations in arterial O_2 or CO_2 concentrations resulting in altered acid-base levels (Bass & Gardner, 1985; Fried, 1987). The somatic symptoms of hyperventilation (overbreathing) have been linked with panic disorder (Clark, Salkovskis, & Chalkley, 1985), agoraphobia (Bonn, Readhead, & Timmons, 1984), emotional arousal (Thayer et al., 1996), and test-anxiety (Ley & Yelich, 1991). Hyperventilation is more likely to occur during situations when active coping possibilities are reduced, such as during apprehension, fear, threat, aversive stimuli, anger, or pain (Seuss, Alexander, Smith, Sweeney, & Marion, 1980; Allen, Sherwood, & Obrist, 1986). The range of symptoms associated with hyperventilation is similar to those associated with stress and anxiety and several studies have demonstrated these similarities using symptom checklists (Grossman, De Swart, & Defares, 1985; Huey & West, 1983). In clinical settings, the link between hyperventilation and anxiety is demonstrated in panic patients by getting them to overbreathe using shallow (or thoracic (TH)), rapid breathing. In this way patients experience the symptoms that result from hyperventilation (Fried, 1987, 1993; Timmons & Ley, 1994). While the apparent similarities between the symptoms of hyperventilation and those of anxiety are compelling, evidence supporting the link is ambiguous (Bass & Gardner, 1985; Grossman & Wientjes, 1989; Wientjes & Grossman, 1994). An alternative view of symptom causes has also been presented (Watson & Pennebaker, 1989), which argues that increased awareness of bodily sensations and subsequent negative appraisal of these sensations explains why anxious individuals experience increased somatic complaints.

Respiratory patterns. Review studies into the effects of induced emotions on respiratory patterns indicate there are four basic breathing patterns (Boiten, Fridja, & Wientjes, 1994; Wientjes, 1992). Of these, rapid, shallow (TH) breathing with high inspiratory flow rate is of interest to the study of GAD because it is associated with mental effort, task performance, tense anticipation, and moderate anxiety and fear. In contrast, rapid and deep abdominal (ABD) breathing with high inspiratory flow rate is associated with excitement and arousal, is most easily observed during unrestrained activity and lacks the control aspect of the former pattern. Slow, shallow breathing, which is characterised by decreased respiratory drive, is associated with withdrawal and passivity and may accompany both unhappy or depressed moods and also happy, unexcited moods. Slow, deep breathing (the opposite of shallow, rapid breathing) is typically observed during resting states (Boiten et al., 1994; Wientjes, 1992). This respiratory pattern is widely documented in studies into relaxation (Lehrer & Woolfolk, 1993; Patel, 1991), active coping during threat (Cappo & Holmes, 1984), anxiety reduction (Clark et al., 1985; Clark & Hirschman, 1994), paced respiration (Montgomery, 1994), and respiratory retraining (Buckholtz, 1994).

These respiratory patterns indicate that respiratory parameters, especially rate and mode contribution differences, underlie different psychological states.

Respiratory modes. Respiratory mode differences have also been linked to personality or dispositional characteristics. Early studies investigating mental illness linked TH breathing with neurotic type patients (Clausen, 1951). Studies have investigated the influence of induced emotion and arousal on TH and ABD modes of breathing under a range of laboratory conditions. Cumulative aversive stimulation resulted in increased TH breathing and decreased ABD breathing (Landis, 1926). During sustained mental tasks that also involved threat of electric stimulation, TH circumference increased, whereas ABD movements did not change (Svebak, Dalen & Storfjell, 1981). Pleasant imagined situations resulted in increased ABD movement, whereas unpleasant imagined situations decreased it (Faulkner, 1941). ABD mode breathing was induced while viewing pleasant films whereas unpleasant films induced TH mode breathing (Ancoli, Kamiya, & Ekman, 1979; Ancoli & Kamiya, 1980). Gender differences were reported when ABD circumference increases predicted increased laughter responses in women, but not in men, in response to comical films (Svebak, 1975). While these findings suggest that respiratory mode contributions vary along a pleasant-unpleasant dimension, contrary findings have also been reported (Boiten, 1998; Mador & Tobin, 1991). Profile analysis was performed on normal slow-deep (ABD) and rapid-shallow (TH) breathers and on the highest and lowest CO_2 sensitivity groups. Opposing life orientations were found for the groups; slow-deep breathers were stable, capable, confident with a dislike for restrictions, while rapid-shallow breathers were found to be unstable, dependent, fearful and shy (Haas, 1980; Haas, Axen, Ehrlichman, & Haas, 1980). Associations have been reported in several studies between respiratory modes and motivational constructs such as the telic and paratelic states described by Apter (1982) as part of reversal theory (which is elaborated below). Telic dominant individuals demonstrated increased ABD amplitude and increased respiration rate (RR) (TH amplitude was not measured) during threat of shock for poor performance versus no-threat conditions (Svebak, Storfjell, & Dalen, 1982), and when performing a perceptual motor task the telic dominant group demonstrated increased TH amplitude (ABD amplitude was not measured) (Svebak & Murgatroyd, 1985). When both TH and ABD measurements were taken, the telic dominant group demonstrated greater overall TH contribution under both threat and no-threat conditions. Under the threat condition the telic dominant group demonstrated increased RR and greater ABD contribution, than their paratelic counterparts (Svebak, 1986). The finding of rapid (TH) and deep (ABD) breathing for the telic dominant group indicated the involvement of hyperventilation. These findings from respiratory studies provide empirical evidence of a relationship between personality and respiratory mode differences in clinical and non-clinical groups. In particular, the results indicate that rapid, TH mode breathing is associated with personality dispositions and unpleasant, tense or fearful conditions.

Reversal theory

Reversal theory (Apter, 1982) proposes that people reverse between telic (arousal-avoiding) and paratelic (arousal-seeking) metamotivational states depending on internal and external contingencies. According to Apter (1989) these states are termed metamotivational because they give rise to different emotions or feelings that are experienced at different levels of positive and negative hedonic tone.

Apter (1988) identified two types of emotions in reversal theory. Somatic emotions that are moderated by felt physiological arousal and transactional emotions that reflect felt gain or loss in response to transactions with people, situations or objects. While reversal theory accounts for two pairs each of somatic and transactional emotions, this study will focus on the somatic telic/paratelic pair as the interpretation of felt-arousal is centrally relevant the present study. The telic mode is serious-minded and pleasure is derived from goal achievement, whereas the paratelic mode is less concerned with goals, but rather with immediate sensation where pleasure is derived from the activity itself.

While some people are balanced in their reversals, others are extremely dominant in their state preference, such that, at any given time they are more likely to be in their preferred state. Telic dominant individuals, for example, will prefer to spend most of their time in a state of low arousal, whereas paratelic dominant individuals prefer to spend more time in a state of high arousal. While reversals to the opposite state do occur, the time spent in the non-dominant state is likely to be brief and less stable (Apter, 1989).

Similarities have been observed between extreme telic dominance and the characteristics of high trait-anxiety. Telic dominant individuals regarded daily bothersome events as threatening in one study (Baker, 1988), while another found that telic dominant people were threatened even by low levels of stress. Paratelic individuals, in contrast, enjoyed relatively high stress levels and reacted negatively to low levels of arousal (Martin, Kuiper, Olinger, & Dobbin, 1987). Individuals high in telic dominance and arousability have also demonstrated significant levels of trait-anxiety (Lafreniere, Gillies, Cowles, & Toner, 1993). In addition, telic dominance, perceived threat, and negative hedonic tone were found to interact with decreased percentage of end-tidal CO_2, which indicates a relationship exists between telic dominance and hyperventilation (Svebak & Grossman, 1985). The relationship between telic dominance and trait-anxiety is of particular importance to the present investigation, where evidence of distinct respiratory mode contribution differences for telic dominant individuals (Svebak et al., 1982; Svebak & Murgatroyd, 1985; Svebak, 1986) may also apply to trait-anxious individuals.

Apter (1989) described how the general principles of reversal theory relate to the understanding of stress using the concepts of tension- and effort-stress. Tension-stress occurs when there is a mismatch between the preferred and actual levels of a variable, such as felt-arousal. A person in the telic state will experience tension-stress if they experience high arousal because they prefer low arousal in that state, or if a person in the paratelic state where high arousal is preferred, experiences low arousal, they will experience tension-stress. An individual may respond to the experience of tension-stress with a degree of effortful striving, known as effort-stress. If the effort that is made is appropriate and made at the right time, a reduction in tension-stress may result (Apter, 1989). Several studies have reported that telic-dominant individuals are more likely to use effortful problem-solving strategies to decrease tension-stress than are their paratelic counterparts (Baker, 1988; Howard, 1988; Murgatroyd, 1985).

In telic dominant persons the tendency towards high-arousability results in more frequent tension-stress (unpleasant anxiety) than in a person with low arousability (Lafreniere et al., 1993). This poor fit between arousal preferences and arousability will increase stress and according to Apter (1982) may lead to psychopathology.

Chronic anxiety for example, could develop as a result of telic dominance (arousal-avoidance), occurring when a person regularly experiences high levels of unpleasant arousal, yet is unable to reverse into their preferred low arousal state. This process in referred to as "inhibited reversal" (Apter, 1989, p. 143).

Summary. Converging empirical evidence from a range of domains of inquiry indicate TH mode breathing may be implicated in trait-anxiety. This evidence draws on findings where the respiratory pattern of rapid, shallow (TH) high inspiratory rate breathing was associated with fear, anxiety, mental effort and task performance (Boiten et al., 1994; Wientjes, 1992). Respiratory dysfunction, including increased TH mode contribution, has also been linked with panic disorder and agoraphobia (Clark et al., 1985; Bonn et al., 1984). In addition, the reversal theory construct of telic dominance demonstrated respiratory mode contribution differences compared with its paratelic counterpart (Svebak et al., 1982; Svebak & Murgatroyd, 1985; Svebak, 1986). Importantly, relationships have been demonstrated between telic dominance and high trait-anxiety (Lafreniere et al., 1993), and between increased tension-stress and telic dominance under conditions of effortful coping (Apter, 1989). Investigations into the parasympathetic nervous system responses of GAD patients have produced mixed results (Lyonfields et al., 1995; Thayer et al., 1996; Davis et al., in press). Where previous findings indicate that RSA typically decreases in response to rapid, shallow (TH), low volume breathing (Grossman, 1983), and in response to unpleasant, or threatening stimuli (Allen & Crowel, 1989, 1990), the issue of how GAD sufferers respond under these conditions is unresolved.

Aim and hypotheses

The aim of the present study is to compare the effect of stress induced by viewing unpleasant stimuli on breathing, autonomic response measures and emotional changes between high and low trait-anxiety groups. Research evidence supports the predictions that high anxiety individuals will demonstrate increased TH breathing compared with low anxiety controls; that TH breathing will increase with the unpleasant emotional induction; that high anxiety individuals will demonstrate lower RSA during unpleasant conditions compared with low anxiety controls; and that the unpleasant emotional induction will result in increased negative emotional changes in high anxiety individuals compared with low anxiety controls.

Method

Participants

Forty participants were selected from the highest and lowest scores following screening of 230 first year psychology students using the Self Evaluation Questionnaire (STAI Form Y 2) of the State Trait Anxiety Inventory (STAI AD) (Spielberger, Gorsuch, Lushene, Vagg, & Jacob, 1983). High ($M = 58.75$) and low ($M = 31.8$) trait-anxiety groups were formed. Participants ranged in age from 18-40 years (High $M = 22.42$ years; Low $M = 22.70$ years) (High: female 18, male 2; Low: female 14, male 6). Exclusion criteria included a medical history of respiratory disease or dysfunction, cigarette smokers, extra respiratory capacity developed through sport, yoga practices or through playing a wind instrument. Six participants were excluded.

Apparatus and materials

Physiological measures. Physiological recording occupied 8 channels of a MacLab 8 Data Acquisition System and a Power Macintosh 7300 computer using Chart v 3.6. A total of 8 channels displayed electrocardiograph (ECG), heart rate (HR), skin conductance level (SCL), finger pulse amplitude (FPA), TH respiration, ABD respiration, tidal volume (V_T) and cumulative expired volume was used to determine minute volume (V_{MIN}).

Miniature Ag-AgCl electrodes (3mm) were used to measure ECG using standard left and right rib placements, with mastoid earth. HR was derived for ECG and displayed on another channel. SCL was measured using two Ag-AgCl electrodes (9mm) fitted to the second phalanx of the first and second fingers of the non-dominant hand. FPA was measured using a photoelectric finger plethysmograph placed around the first phalanx of the second finger of the non-dominant hand. Pulse heights were computed from FPA signals and displayed on a separate channel. Respiratory girth measurement transducer belts were fitted to the TH (upper chest at armpit level) and to the ABD (waist at the umbilical level) and girth changes were measured using a Vitalog Respiration and Body Position Amplifier. RSA was determined off screen from ECG, HR and respiratory records.

MacLab respiratory calibration equipment comprised a Respiratory Flow-head (MLT 300 L) and a Spirometer amplifier (ML 140). Other apparatus included a spirometer, a gas syringe, a non-return valve (Hans Rudolph Inc. 2600 Series NRBV) (23.00 mm I.D), spirometry tubing (18 mm I.D./ 23.00 mm O.D.), disposable respiratory bacterial filters with in-built mouthpiece, and disposable nose clips.

Psychological measures. Both State and Trait anxiety were assessed separately using the STAI-AD (Spielberger et al., 1983). Level of Trait anxiety (Form 2-Y) was used as a criterion to select participants for the experiment. State-anxiety (Form X-2) was assessed when participants arrived in the laboratory prior to starting the experiment.

Changes in positive and negative somatic emotions were assessed using the Tension-Stress (Section 3) of the Tension and Effort Stress Inventory (TESI) (Svebak, 1993). Visual Analogue Scales (VAS) were used as a manipulation check to measure stress, arousal and hedonic tone (King, Stanley, & Burrows, 1987). A TESI and a VAS (See Appendix A.) was administered following each exposure to the Affective Picture blocks.

Fifty four colour pictures were selected from the International Affective Picture System (IAPS) (Lang, Ohman, & Vaitl, 1988) on the basis of normative ratings. Pictures were presented in three blocks depicting either pleasant, neutral or negative contents. Each picture block comprised 18 pleasant contents (e.g., children, food, scenes, etc.), 18 neutral contents (e.g., neutral faces, household objects, buildings) and 18 unpleasant contents (accidents, mutilations, spiders, snakes etc.). For each picture block, individual pictures were presented for 10 seconds, pictures changed automatically. There was a two-three minute break between picture blocks to enable participants to complete TESI and VAS questionnaires. Order of presentation of the picture blocks was counterbalanced, so that each picture block was seen equally often in the first, second and third positions. Selection of stimuli was based on the same set of stimuli used in previous experiments (Bradley, Cuthbert, & Young, 1991; Bonnet, Bradley, Lang, & Requin, 1995). Some minor alterations were made where opposite sex nudes were replaced with other picture content types to eliminate the assumption of opposite sex attraction (See Appendix B. for index of pictures used). Replacement stimuli were matched for valence, arousal and dominance. The affective picture block was stored on a CD-ROM and the presentation was made using Microsoft Powerpoint on a 486 IBM computer. Picture presentation blocks were started by computer mouse and participants were instructed via a two-way intercom system when to start each block of slides.

Procedure

Calibration for respiratory inductive plethysmography (RIP). Detailed descriptions of RIP have been published relating the advantages of non-invasive respiratory measurement techniques. Important in the use of non-invasive techniques are calibration procedures to facilitate the estimation of separate TH and ABD contributions to breathing, relative to respiratory volume (Watson, 1980; Gribbin, 1983; Chadha et al., 1982). Underlying the present calibration procedure is a 2-degrees of freedom chest-movement model developed by Konno and Mead (1967). These researchers used isovolume manoeuvres where the subject shifted respiratory volume between the TH and ABD compartments with the glottis closed. This model assumes that volume measured at the mouth is equal to the sum of the volume changes of the TH and ABD compartments. As the isovolume manoeuvre is difficult to perform, calibration procedures that require subject cooperation have been adopted for use with RIP, based on the 2-degrees of freedom model to determine volume-to-motion coefficients for estimating volume (Gribbin, 1983). These calibration procedures have been used during natural breathing in normal and diseased patients (Tobin et al., 1983a, 1983b).

Calibration involved two separate procedures for each participant. First, TH and ABD electrical gains (mV) of the RIP amplifiers were used to calibrate two respective computer channels, so that the sensitivities of the Vitalog Respiratory and Body Position amplifier for the TH and ABD channels could be set so that 3 cm of belt movement produced a 2.00 volt signal. Second, a gas syringe was used to calibrate the spirometry channel for respiratory volume so that exhaled air displayed a signal with a trigger cut-off set at 5 lt. During recording of respiratory volume, a 4-channel audio interval generator alternately produced a 1 kHz and 1.5 kHz tone which was used to pace respiration.

Respiratory calibration. The participant was then taken into the adjoining recording room for the respiratory calibration procedure, where they were seated in a comfortable, upright position that excluded sight of the computer screen. The spirometry channel was calibrated for respiratory volume by first injecting 500 ml from a gas syringe through the spirometer. This enabled a corresponding computer channel to be scaled to an equivalent volume and an expired air trigger cut-off to be set. Following computer calibration a disposable respiratory filter with mouth piece, which was attached to a respiratory flow device, was placed in the participants mouth and a nose clip was attached to prevent additional air from entering the respiratory system. Participants were asked to match their respiratory rate to that of an auditory tone. The respiratory V_T of 15 to 20 breaths was recorded at the rates of 10, 12, 15, and 20 breaths per minute. Respiratory belts were then removed, the participant was debriefed and thanked for participation.

Experimental session. The experiment was conducted in a single session between the hours of 8.00 am -12.00 am and 2.00 pm - 6.00 pm. Participants were instructed not to eat or drink for one hour prior to the experiment. Upon arrival at the psychophysiology laboratory, sufficient information was provided about the experiment to enable Informed Consent to be obtained (see Appendix C.). Participants completed questionnaires for State-anxiety (Form X-2 of the STAI-AD), as well as TESI and VAS questionnaires.

Before each experimental session the respiratory (TH and ABD) strain gauges were calibrated by simultaneously fixing the ends of both respiratory belts to a bench with a single 3 mm pin inserted into the benchtop through the belt catches. The free ends of the belts were then stretched over a scale on the benchtop. Both respiratory belts were stretched several times while the resulting signals were recorded. This enabled belt movement to be scaled to a voltage level for the respective computer channels.

Electrodes and transducers were fitted according to standard laboratory procedures. Participants were seated in a comfortable upright position, 450 mm from a computer monitor during the experiment. Participants were advised that some instructions would be given via a two-way intercom system from an adjoining recording room. In particular, directions about how to start the picture sets using the computer mouse were provided. Instructions were also given for participants to keep their eyes open, look at the screen at all times, and to breathe naturally during the experiment. A baseline recording was taken before the experimental sequence to facilitate calculation of change scores for FPA and SCL measures. Participants underwent 3 blocks of pleasant, neutral and negative valence picture contents that were counterbalanced between participants. Each block lasted 3 minutes (18 slides x 10 second exposure each). A two-three minute break was allowed between blocks to allow completion of a TESI and VAS, and to reduce emotional and physical carryover. Following the experimental sequence, electrodes and transducers were removed from the participant except for the respiration belts.

Data scoring

Physiological measures. Respiratory measures were scored on a breath-by-breath basis from the last 60 seconds of records for each affective condition to produce mean values for each affective picture block. Respiratory measures included; TH and ABD mean voltage differences which were used to calculate percentage TH contribution (TH%) relative to ABD contribution using the formula [TH/(TH-ABD) x 100/1], respiratory minute frequency (RR), average estimated V_T, and V_{MIN}.

Average estimated V_T was calculated for each participant using multiple linear regression analysis. For this, volume-to-motion coefficients and corresponding volume of expired air were derived for each participant from recorded signals at paced respiratory rates of 10, 12, 15, 20 breaths per minute, and TH and ABD mean voltage differences. Multiple regression analysis of this data yielded coefficients for volume (β, $\beta 2$), and constant (*c*) for each breath in the selected scoring segment which were then used with movement (TH, ABD) to predict V_T using the formula: $V_T = [\beta 1 \text{ x TH} + \beta 2 \text{ x ABD} + c]$ (Gribbin, 1983; Watson, 1980; Wientjes, 1992). V_{MIN} was the product of V_T x RR

Other physiological measures such as HR (bpm), SCL (μS), FPA (mV) were scored from the last 60 seconds of recorded data to produce mean values. HR and RSA (bpm) were derived for each condition using HR and respiratory records. RSA was scored using the peak-to-trough method which involved measuring the difference between maximum and minimum HR associated with each respiratory cycle to produce RSA means for all conditions (Grossman & Svebak, 1987). FPA was scored as a percentage change from a baseline level, where scores over 100% indicated increased sympathetic arousal, scores below 100% indicated a decrease in sympathetic activity. SCL was scored as the mean response minus baseline level for each condition.

Psychological measures. State-Trait Anxiety Inventory (STAI-AD) measures used standard scoring procedures (Spielberger et al., 1983). The eight TESI measures of mood/emotional change were expressed as scores from1 (*Not at all*) to 7 (*Very much*). The three VAS measures required participants to place a mark on a 7 cm continuous line for each of the *Calm-Worried* (1-7), *Active-Sleepy* (7-1) and *Pleasant-Unpleasant* (1-7) dimensions. Each 7 cm line was scored in mm and converted to percentage of total.

Data analysis

Physiological variables. The dependent variables V_{MIN}, RR, TH%, HR, RSA, FPA%, and SCL were analysed using separate 3 x 2 mixed measures MANOVAs for each physiological variable. The within subjects factor was Condition (positive, neutral and negative Affective Picture conditions) and the between subjects factor was Group (high/low anxiety).

Psychological variables. Psychological variables were analysed using three separate doubly multivariate mixed measures MANOVAs. The first analysis used a 4 x 3 x 2 design where the repeated measures within subjects factors were Positive TESI Emotions (relaxation, excitement, placidity, provocativeness), Condition (positive, neutral, negative Affective Picture conditions), and the between subjects factor was

Group (high/low trait-anxiety). The second analysis used a 4 x 3 x 2 mixed design where the repeated measures within subjects factors were Negative TESI Emotions (anxiety, boredom, anger, and sullenness), Condition (positive, neutral, negative Affective Picture conditions), and the between subjects factor was Group (high/low trait-anxiety). The third analysis used a 3 x 3 x 2 mixed design where the repeated measures within subjects factors were VAS (stress, arousal, and hedonic tone), Condition (positive, neutral, negative Affective Picture conditions), and the between subjects factor was Group (high/low trait-anxiety).

MANOVAs for physiological and psychological variables utilised the Pillai's Trace statistic. MANOVA is the preferred method of analysis when multiple repeated measures are involved (Vasey & Thayer, 1987). Primary analyses were performed on groupings of Positive TESI emotions, Negative TESI emotions, and VAS variables when there were significant effects in the primary MANOVAs. Secondary repeated measures MANOVAs were performed on each TESI or VAS measure to identify specific TESI emotions or specific VAS variables involved in significant effects in the primary MANOVAs. Protected t-tests were used where necessary to interpret significant effects revealed by either of the physiological or secondary psychological MANOVAs (Maxwell & Delaney, 1989). The statistical analysis procedure minimised Type 1 error rate for both types of comparison by reducing the number of primary analyses given the large number of dependent variables and ensured that the number of subjects was larger than the number of repeated measures for subjects in any condition. The α level of .05 was used for all statistical tests, following Fischer's LSD technique (Maxwell & Delaney, 1989).

Results

Independent t-test analyses were conducted for the State-Trait Anxiety Inventory (STAI-AD) measures and for age. As expected as they were selected on the basis of trait-anxiety, group differences were found for state-anxiety, t (37) = 5.393, p < .001, for trait-anxiety, t (37) = 18.902, p < .001, and age differences between groups were not significant. Chi-square analysis for gender indicated differences between groups were not significant, χ^2 (df = 1), 1.406.

Physiological variables

One outlying univariate (TH%) case with a low score across all conditions was identified from the means. Tests of Normality in SPSS indicated that inclusion of the case reduced significance of deviation from Normality for the Shapiro-Wilk statistic from $p < .036$ to $p = .117$. The case was subsequently deleted from the high anxiety group prior to analysis, leaving 19 cases in that group. Because the groups were formed from the upper and lower quartiles of anxiety questionnaire respondents, it was likely that this low TH% case was a more appropriate fit in the central quartiles.

Separate repeated measures MANOVAs were used to analyse the following dependent variables: TH%, RR, V_{MIN}, HR, RSA, SCL, and FPA%. A table of means and standard deviations is provided in Table 1. (See Appendix D. for all MANOVA tables).

TH%. Significant main effects were found by MANOVA for Condition, Pillai's Trace = .238, F (2, 36) = 5.618, p = .008, power = .828, for Group, F (1, 37) = 8.590, p = .006, power = .814, and a significant interaction was found for Condition x Group, Pillai's Trace = .223, F (2, 36) = 5.168, p = .011, power = .794; this interaction is graphed in Figure 1. Further analysis indicated there was significantly more TH% contribution in the pleasant compared to the neutral condition, t (38) = 3.355, $p = .002$, and a significantly greater TH% contribution was observed during the unpleasant condition compared to the pleasant condition, t (38) = 3.024, $p = .004$. There was no difference between the neutral and unpleasant conditions. The low anxiety group demonstrated significantly greater TH% contribution during the pleasant condition compared with the neutral condition, t (19) = 3.699, $p = .002$, and during the pleasant condition compared with the unpleasant condition, t (19) = 4.484, $p < .001$. The high anxiety group recorded significantly greater TH% contribution during the neutral, t (37) = 3.920, $p < .001$, and unpleasant conditions, t (37) = 5.287, $p = < .001$, compared with the low anxiety group.

RR. MANOVA revealed no significant main effects or interaction for Condition or Group.

V_{MIN}. MANOVA revealed no significant main effects for Condition or Group. A significant interaction was found for Condition x Group, Pillai's Trace = .183, F (2 ,36) = 4.029, $p = .026$, power = .682; this interaction is graphed in Figure 2. Further analysis indicated that within the high anxiety group V_{MIN} was significantly greater during the unpleasant condition than during the neutral condition, t (18) = -2.577, $p = .019$. The pleasant condition was not significantly different from the neutral or unpleasant conditions.

RSA, HR, SCL, and FPA%. MANOVA revealed no significant main effects or interactions for Condition or Group for these variables.

Table 1. *Means and (Standard Deviations) of High and Low Trait-Anxiety Groups for Pleasant, Neutral and Unpleasant Picture Conditions for Thoracic Percentage Contribution (TH%), Respiration Rate (RR), Minute Volume (V_{MIN}), Heart Rate (HR), Respiratory Sinus Arrhythmia (RSA), Skin Conductance Level (SCL), and Finger Pulse Amplitude Percentage of Baseline (FPA%).*

		High Trait-Anxiety			Low Trait-Anxiety		
		Pleasant	Neutral	Unpleasant	Pleasant	Neutral	Unpleasant
TH%	**M**	63.43	57.21	60.89	63.19	44.52	41.80
	(SD)	(24.72)	(9.82)	(12.64)	(21.65)	(10.37)	(9.97)
RR	**M**	15.66	15.21	16.50	15.20	14.90	14.62
	(SD)	(2.71)	(2.66)	(1.70)	(3.16)	(3.35)	(3.42)
V_{MIN}	**M**	7.26	7.00	7.75	8.99	8.76	8.39
	(SD)	(4.19)	(3.99)	(4.17)	(6.50)	(6.13)	(5.97)
HR	**M**	75.40	75.81	77.07	76.21	76.73	73.88
	(SD)	(11.11)	(11.14)	(15.71)	(9.59)	(9.19)	(8.83)
RSA	**M**	9.55	9.09	10.22	9.14	7.62	8.47
	(SD)	(4.06)	(4.55)	(4.94)	(4.93)	(4.14)	(4.36)
SCL	**M**	35.23	35.63	37.66	38.74	38.93	40.03
	(SD)	(15.86)	(15.09)	(16.42)	(17.66)	(15.90)	(14.97)
FPA%	**M**	97.73	99.49	100.24	99.64	101.98	100.92
	(SD)	(4.81)	(8.41)	(7.60)	(7.89)	(8.99)	(11.34)

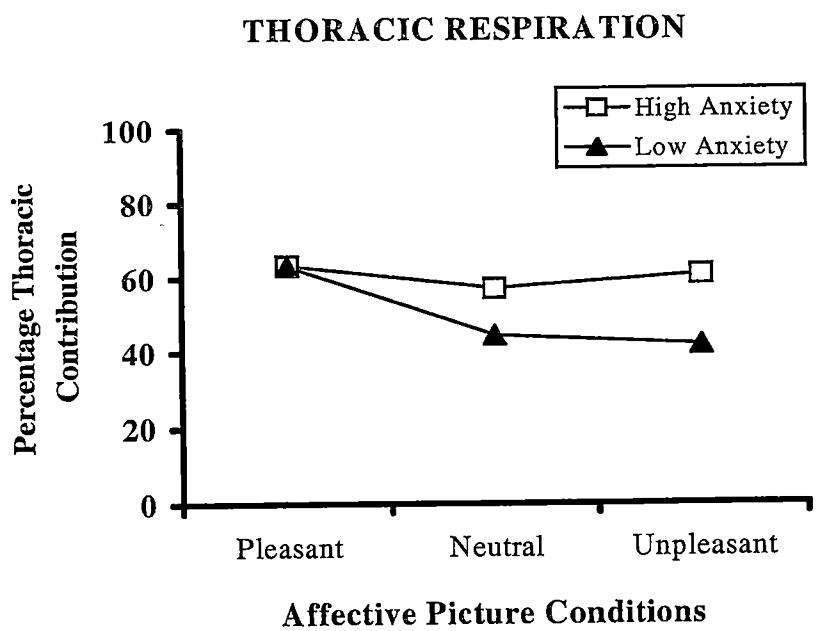

Figure 1. Mean percentage thoracic (TH%) contribution for high and low trait-anxiety groups in response to pleasant, neutral and unpleasant affective picture stimuli.

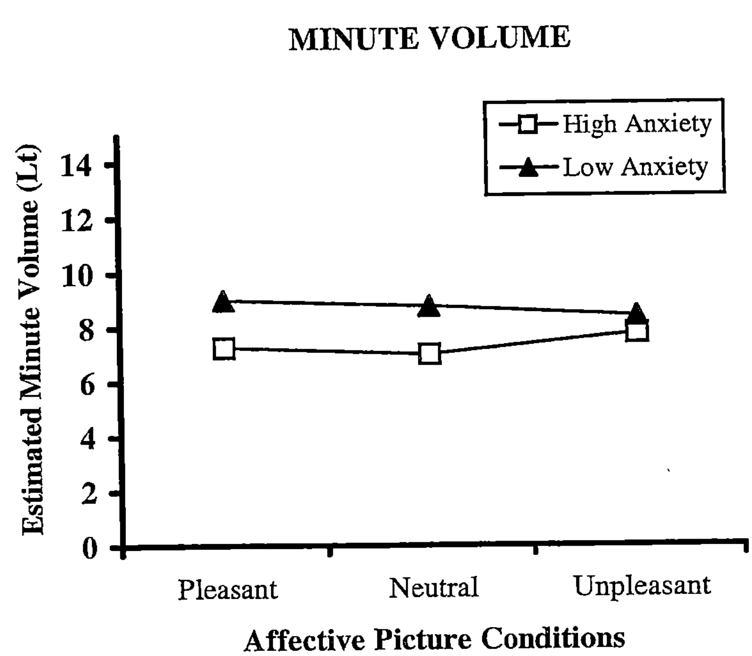

Figure 2. Mean estimated minute volume (V_{MIN}) for high and low trait-anxiety groups in response to pleasant, neutral and unpleasant affective picture stimuli.

Psychological variables

Doubly multivariate MANOVAs were performed for the Positive TESI Emotions, Negative TESI Emotions, and VAS factor variables. A table of means and standard deviations is provided in Table 2.

Positive TESI Emotions

Significant main effects were found by MANOVA for Condition, Pillai's Trace = .358, F (2, 36) = 10.046, p = < .001, power = .977, and for Positive TESI Emotions, Pillai's Trace = .889, F (3, 35) = 93.070, p = < .001, power = 1.000. Significant interactions were found between Positive TESI Emotions and Group, Pillai's Trace = .199, F (3, 35) = 2.895, p = .049, power = .640, and between Condition and Positive TESI Emotions, Pillai's Trace = .533, F (6, 32) = 6.591, p < .001, power = .997. Separate repeated measures MANOVAs were conducted for each of the four Positive TESI emotions (See Figures 3, 4, 5), to identify the specific emotions involved in the significant effects.

Relaxation. Significant main effects were found by MANOVA for Condition, Pillai's Trace = .489, F (2, 36) = 17.026, p < .001, power = .999, and for Group, F (1, 37) = 6.322, p = .016, power = .688. There was no significant interaction. Further analysis indicated that participants were significantly less relaxed during the unpleasant condition than during the neutral condition, t (38) = 5.821, p < .001, and significantly less relaxed during the unpleasant condition than during the pleasant condition, t (38) = 4.666, p < .001. Comparisons between the pleasant condition and neutral conditions were not significant. The group effect occurred because (overall) the high anxiety group was less relaxed than the low anxiety group.

Excitement. MANOVA revealed no significant main effects or interactions for Condition or Group.

Placidity. A significant main effect was found by MANOVA for Condition, Pillai's Trace = .289, F (2, 36) = 7.320, p = .002, power = .918. There was no significant effect for Group and no interaction. Further analysis indicated that participants were significantly less placid during the unpleasant condition than during the neutral condition, t (38) = 3.916, p < 001, and significantly less placid during the unpleasant condition compared with the pleasant condition, t (38) = 3.399, p = .002. Comparisons between the pleasant condition and neutral conditions were not significant.

Provocativeness. A significant main effect was found by MANOVA for Condition, Pillai's Trace = .274, F (2, 36) = 6.809, p = .003, power = .897. There was no significant effect for Group or interaction. Further analysis indicated that participants were significantly more provocative during the pleasant condition compared with the neutral condition, t (38) = 2.919, p = .006. Comparisons between the pleasant and unpleasant conditions, and the unpleasant and neutral conditions were not significant.

Negative TESI Emotions

Significant main effects were found by MANOVA for Condition, Pillai's Trace = .229, F (2, 36) = 5.334, p = .009, power = .807, and for Negative TESI Emotions, Pillai's Trace = .617, F (3, 35) = 18.758, p < .001, power = 1.000. An interaction was found for Condition and Negative TESI Emotions, Pillai's Trace = .504, F (6, 32) = 5.418, p < .001, power = .986. Separate repeated measures MANOVAs were conducted for each of the four Negative TESI Emotions (See Figures 3, 4, 5) to identify the specific emotions involved in the significant effects.

Anxiety. Significant main effects were found by MANOVA for Condition, Pillai's Trace = .490, F (2, 36) = 17.325, $p < .001$, power = 1.000, and for Group, F (1, 37) = 4.088, p = .050, power = .504. There was no significant interaction. Further analysis indicated that participants were significantly more anxious during the unpleasant condition than during the neutral condition, t (38) = -5.843, $p < .001$, and significantly more anxious during the unpleasant condition than during the pleasant condition, t (38) = -4.345, $p < .001$. Comparisons of participant anxiety between the pleasant condition and neutral conditions were not significant. The group effect occurred because (overall) the high anxiety group was significantly more anxious compared with the low anxiety group.

Boredom. A significant main effect was found by MANOVA for Condition, Pillai's Trace = .229, F (2, 36) = 5.348, p = .009, power = .808. There was no significant effect for Group or interaction. Further analysis indicated that participants were significantly more bored during the neutral condition than during the pleasant condition, t (38) = -3.340, p = .002, and were significantly more bored during the neutral condition than during the unpleasant condition, t (38) = 2.693, p = .010. Comparisons between the pleasant condition and neutral conditions were not significant.

Anger. A significant main effect was found for Group, F (1, 37) = 5.440, p = .025, power = .622. There was no significant effect for Condition or interaction. The group

Table 2. *Means and (Standard Deviations) of Positive and Negative Somatic TESI Emotion Responses for the High and Low Trait-Anxiety Groups for Pleasant, Neutral and Unpleasant Picture Conditions.*

		High Trait-Anxiety			Low Trait-Anxiety		
		Pleasant	Neutral	Unpleasant	Pleasant	Neutral	Unpleasant
Positive Emotions:							
Relaxation	**M**	4.89	4.89	3.53	5.60	5.75	4.45
	(SD)	(1.15)	(1.31)	(1.26)	(1.46)	(1.41)	(1.61)
Excitement	**M**	2.74	2.79	3.16	3.25	2.95	3.05
	(SD)	(1.05)	(1.18)	(1.12)	(1.16)	(1.23)	(1.28)
Placidity	**M**	4.32	4.26	3.12	4.60	4.90	3.65
	(SD)	(1.70)	(1.73)	(1.29)	(1.82)	(1.68)	(1.63)
Provocativeness	**M**	1.68	1.32	1.79	1.35	1.20	1.20
	(SD)	(1.06)	(0.58)	(1.08)	(0.59)	(0.52)	(0.41)
Negative Emotions:							
Anxiety	**M**	2.47	2.21	3.79	1.85	1.80	3.00
	(SD)	(1.12)	(1.13)	(1.51)	(1.42)	(1.20)	(1.49)
Boredom	**M**	2.00	2.74	1.95	2.40	3.15	2.40
	(SD)	(1.29)	(1.82)	(1.18)	(1.35)	(1.76)	(1.39)
Anger	**M**	1.68	1.42	2.00	1.00	1.15	1.50
	(SD)	(1.20)	(0.84)	(1.49)	(0.00)	(0.49)	(0.95)
Sullenness	**M**	1.89	1.63	1.74	1.20	1.10	1.30
	(SD)	(1.41)	(1.07)	(1.15)	(0.70)	(0.45)	(0.57)

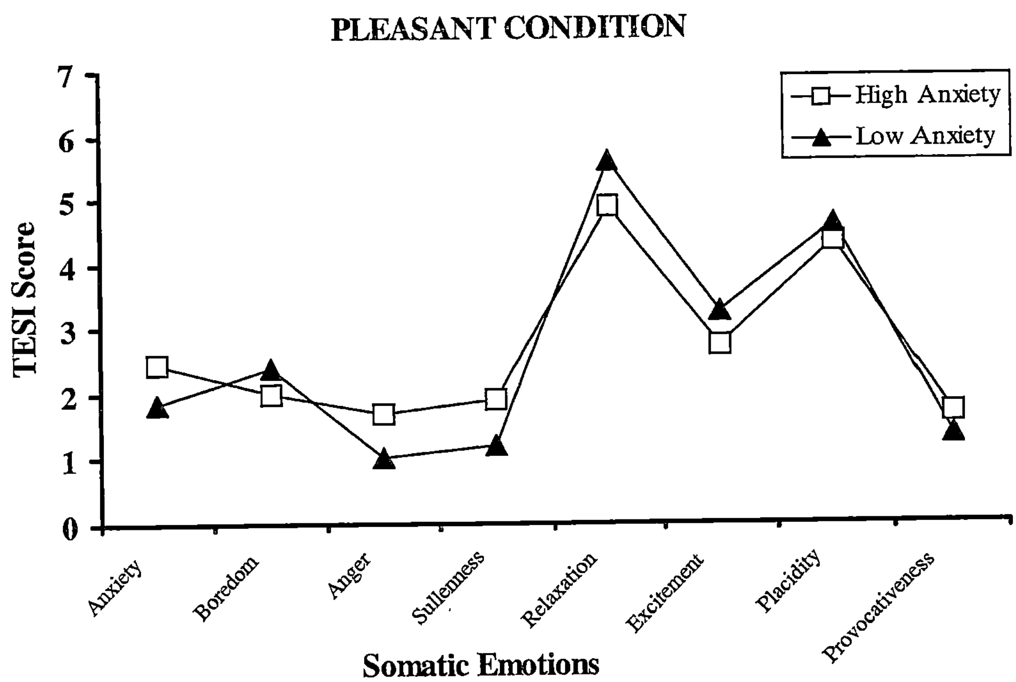

Figure 3. Mean Negative and Positive TESI Somatic Emotion responses to the pleasant affective picture stimuli for high and low trait-anxiety groups.

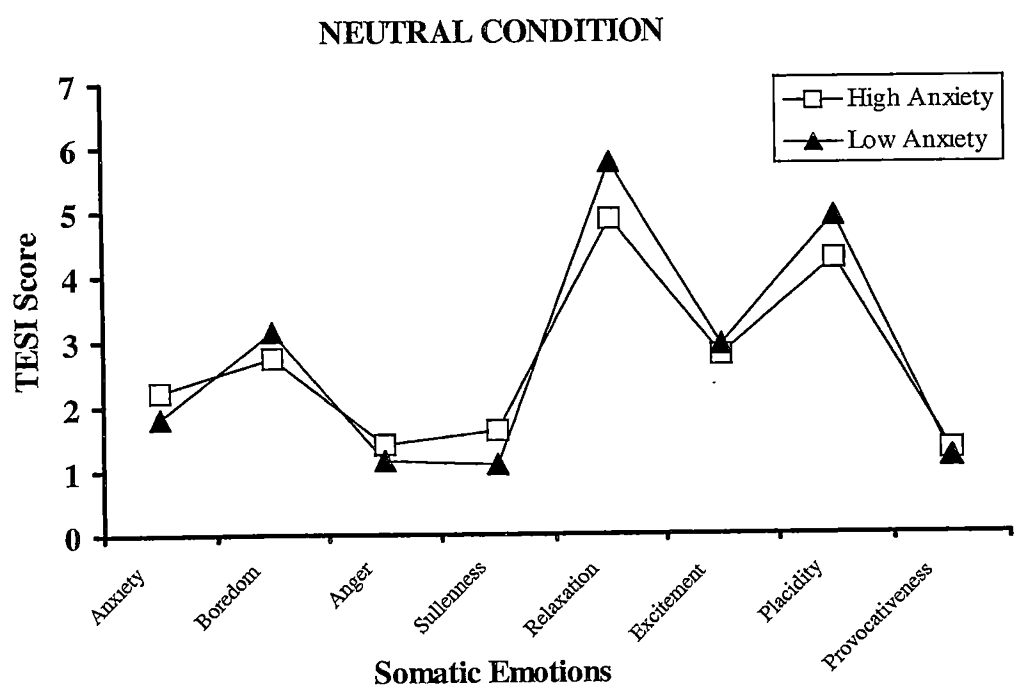

Figure 4. Mean Negative and Positive TESI Somatic Emotion responses to the neutral affective picture stimuli for high and low trait-anxiety groups.

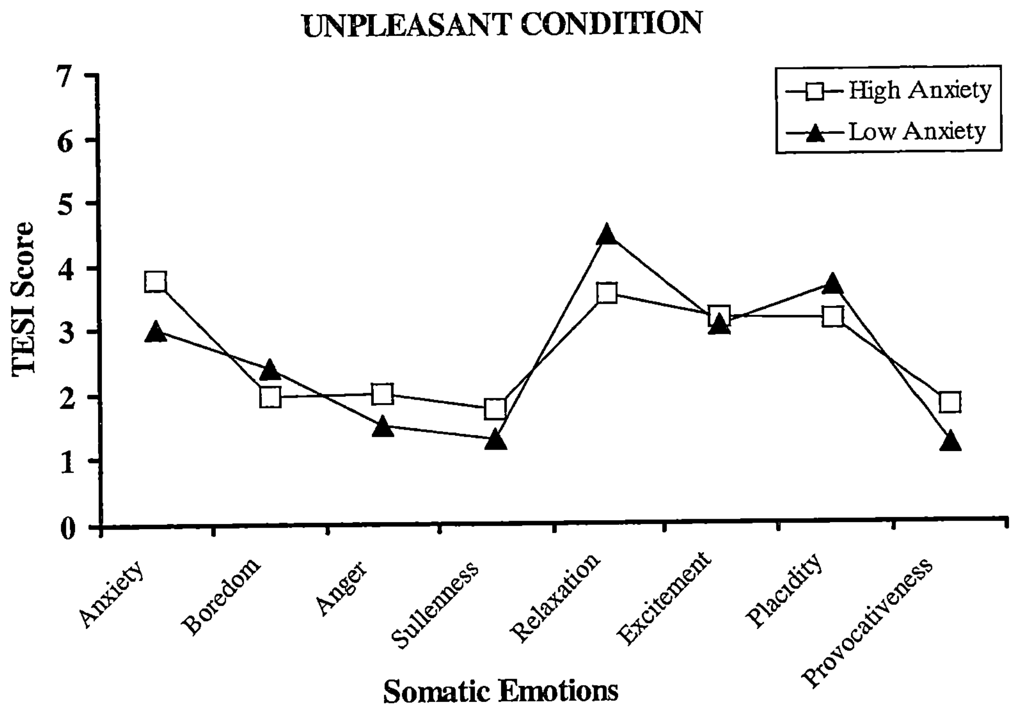

Figure 5. Mean Negative and Positive TESI Somatic Emotion responses to the unpleasant affective picture stimuli for high and low trait-anxiety groups.

effect occurred because (overall) the high anxiety group reported significantly greater anger than the low anxiety group.

Sullenness. Significant main effects were found by MANOVA for Condition, Pillai's Trace = .207, F (2, 36) = 4.686, p = .016, power = .751, and for Group, F (1, 37) = 4.442, p = .042 , power = .537. There was no significant interaction. Further analysis indicated that participants were significantly more sullen during the pleasant condition than during the neutral condition, t (38) = 2.016, p = .050. Comparisons between the pleasant and unpleasant conditions and the neutral and unpleasant conditions were not significant. The group effect occurred because (overall) the high anxiety group was significantly more sullen than the low anxiety group.

Visual analogue scales

A doubly multivariate repeated measures MANOVA was performed for the visual analogue scale variables. See table of means and standard deviations in Table 3. Significant main effects were found by MANOVA for Condition, Pillai's Trace = .474, F (2, 36) = 16.242, p = < .001, power = .999, and for the Visual Analogue Scales, Pillai's Trace = .561, F (2, 36) = 22.964, p = < .001, power = 1.000. Separate repeated measures MANOVAs were conducted for each of the visual analogue scale variables to identify specific variables for the significant effects.

Stress: Calm-Worried. Significant main effects were found by MANOVA for Condition, Pillai's Trace = .371, F (2, 36) = 10.604, p < .001, power = .983, and for Group, F (1, 37) = 6.845, p = .013, power = .722. There was no significant interaction. Further analysis indicated that participants were significantly more stressed during the unpleasant condition compared with the neutral condition, t (38) = -5.372, p < .001, and significantly more stressed during the unpleasant condition than during the pleasant condition, t (38) = -2.648, p < .001. Comparisons between the pleasant condition and neutral conditions were not significant. The group effect occurred because (overall) the high anxiety group was significantly more stressed than the low anxiety group.

Arousal: Active-Sleepy. A significant main effect was found by MANOVA for Condition, Pillai's Trace = .433, F (2, 36) = 13.736, p < .001, power = .977. There was no significant effect for Group or interaction. Further analysis indicated that participants were significantly more aroused during the pleasant condition than during the neutral condition, t (38) = 2.896, p = .006, significantly more aroused during the unpleasant condition than during the neutral condition, t (38) = -5.372,

Table 3. *Means and (Standard Deviations) of Visual Analogue Scales (Stress, Arousal, Hedonic Tone) for the High and Low Trait-Anxiety Groups for Pleasant, Neutral and Unpleasant Picture Conditions.*

		High Trait-Anxiety			Low Trait-Anxiety		
		Pleasant	Neutral	Unpleasant	Pleasant	Neutral	Unpleasant
Stress:							
Calm-Worried	**M**	1.88	1.97	3.55	0.96	1.14	2.16
	(SD)	(1.66)	(1.79)	(1.86)	(0.80)	(1.29)	(1.55)
Arousal:							
Sleepy-Active	**M**	3.18	2.67	4.03	3.99	3.09	4.53
	(SD)	(1.76)	(1.74)	(1.77)	(1.61)	(1.78)	(1.63)
Hedonic Tone:							
Pleasant-Unpleasant	**M**	1.68	1.96	3.14	1.09	1.00	2.36
	(SD)	(1.49)	(1.29)	(1.95)	(1.19)	(1.02)	(1.60)

$p < .001$, and significantly more aroused during the unpleasant condition than during the pleasant condition, t (38) = -2.648, $p = .012$.

Hedonic Tone: Pleasant-Unpleasant. Significant main effects were found by MANOVA for Condition, Pillai's Trace = 412, F (2, 36) = 12.592, $p < .001$, power = .994, and for Group, F (1, 37) = 5.506, $p = .024$, power = .628. There was no significant interaction. Further analysis indicated that hedonic tone was significantly lower during the unpleasant condition compared with the neutral condition, t (38) = -5.145, $p < .001$, and significantly lower during the unpleasant condition compared with the pleasant condition, t (38) = -4.012, $p < .001$. Comparisons between the pleasant condition and neutral conditions were not significant. The group effect occurred because (overall) the high anxiety group experienced significantly lower hedonic tone compared with the low anxiety group.

Discussion

As predicted the high anxiety group demonstrated significantly greater TH mode contributions compared with controls. Respiratory sinus arrhythmia failed to differentiate groups during the unpleasant condition and respiratory and psychological changes took place in the absence of other autonomic response differences between the groups. The prediction that high anxiety individuals would demonstrate greater tension-stress compared with controls was confirmed. Stress, arousal and hedonic tone ratings differentiated the pleasant and unpleasant conditions and the high anxiety group was more stressed and had lower hedonic tone than controls.

Physiological responses

Respiratory responses. The results confirmed greater TH mode contribution by the high anxiety group in response to the unpleasant condition compared with the low anxiety group. A group difference in the same direction that was not predicted, was also found in response to the neutral condition. The TH mode contributions were significantly higher in response to the unpleasant condition compared with the pleasant condition, and significantly higher in response to the pleasant condition compared with the neutral condition. The low anxiety group demonstrated significantly greater TH breathing in response to the pleasant condition compared with either the neutral or unpleasant conditions. The finding of increased TH mode contribution in response to the unpleasant condition supports previous findings where TH mode breathing was associated with unpleasant or threatening stimuli (Ancoli et al., 1979; Ancoli & Kamiya, 1980; Faulkner, 1941; Landis, 1926; Svebak, 1975; Svebak et al., 1981).

An explanation concerning why the high anxiety group demonstrated significantly increased TH breathing in response to the neutral condition compared with the low anxiety group, is warranted. As the experiment was conducted immediately prior to the examination period, the increased TH breathing may have been due to pre-exam high stress levels. As such, the high anxiety group may have been maximally stressed, and subsequently more likely to interpret the overall laboratory experience as being unpleasant. This would explain the lack of response differentiation between the neutral and unpleasant conditions for this measure. It is also possible that some of the neutral condition contents were stark and may have been interpreted as being unpleasant. In contrast, response gradients for the low anxiety group were consistent with the predicted direction of differences between the affective conditions. It is also necessary to explain why the low anxiety group demonstrated significantly higher TH breathing during the pleasant condition compared with the neutral and unpleasant conditions. In this case, it is possible this occurred because low anxiety participants increased their ABD contribution as a learned or adaptive response to stress during the neutral and unpleasant conditions. This explanation aligns with findings from studies where RR reduction and the use of ABD mode breathing have contributed to stress reduction and increased coping (Clark et al., 1985; Grossman et al., 1985; Salkovskis et al., 1986).

The high anxiety group responded to the unpleasant condition with significantly increased V_{MIN} compared with the neutral condition. While no predictions were made for the RR and V_{MIN} measures, the respiratory responses of the high anxiety group fits the pattern of rapid, shallow (TH) breathing with increased flow rate frequently identified with tension, anxiety and mental effort (Boiten et al., 1994; Wientjes, 1992). This was evident in response to the unpleasant condition as increased TH mode contribution, and non-significantly higher RR between the groups, and significantly higher V_{MIN} within the high-anxiety group relative to the other conditions. A dissimilar pattern of results was found by Masaoka and Homma (1997) when they exposed trait-anxious individuals to a mental stressor. RR increased significantly more than V_T in the anxiety group which stands in contrast with the present results. Unfortunately, because these researchers did not measure respiratory mode responses comparison with the present study is limited, though the finding that trait-anxious individuals did not hyperventilate under stress was important. The respiratory results of the present study provide further evidence of a relationship between anxiety, altered respiratory parameters and personality characteristics (Haas, 1980; Haas et al., 1980; Svebak, 1986; Svebak & Murgatroyd, 1985).

Autonomic responses. Contrary to prediction, RSA did not decrease in response to the unpleasant condition for the high anxiety group, in fact there was no significant difference between groups for any stimuli. This deviates from previous findings where typically, HR increased and RSA decreased in response to rapid, TH mode, low V_T breathing (Grossman, 1983), and in response to unpleasant or threatening stimuli (Allen & Crowell, 1989; 1990; Lane et al., 1992). The results support the finding that RSA differences did not occur in worriers in response to stressful tasks, compared with non-worry controls (Davis et al., in press). Sympathetic measures (SCL and FPA) also failed to differentiate groups. This finding is consistent with the removal of autonomic hyperactivity as a GAD diagnostic criterion from the former DSM-III R (APA, 1987). The lack of autonomic differentiation may be due to the use of high trait-anxious student participants (who had not presented for treatment with clinical symptoms), rather than using clinical GAD patients.

These present findings indicate that increased TH mode breathing may be a better index of GAD than autonomic measures. This is supported by indications that the most consistent finding in GAD patients is increased EMG, evident as striate muscle tension (Hazlett et al., 1994; Hoehn-Saric et al., 1989). According to Lehrer and Woolfolk (1994) when the 'fight-flight' response is activated, TH mode breathing is required for inspiration because the diaphragm is less able to move against the tensed striate muscles of the abdomen below it. Given the chronic levels of apprehension and threat associated with GAD, it is likely that habitual increased muscle tension is linked to respiratory mode contribution patterns in this way.

Psychological responses

For the positive somatic emotions, relaxation was significantly lower in the high anxiety group. Relaxation and placidity differentiated the unpleasant condition from both the pleasant and neutral conditions where participants were significantly less relaxed and less placid during the unpleasant condition. For the negative somatic emotions, the high arousal emotions of anxiety and anger, and the low arousal emotion of sullenness were significantly higher in the high anxiety group, compared with controls. The increase in the low arousal emotion of sullenness is consistent with the predicted increase in negative emotion, but deviates in terms of the arousal level. Anxiety was higher in response to the unpleasant compared with the pleasant condition, and provocativeness was higher in response to the pleasant compared with the neutral condition.

Significant group differences in VAS Stress and VAS Hedonic Tone ratings indicate the high anxiety group was more worried, and found the experience more unpleasant than their low anxiety counterparts. These findings are internally consistent with the negative emotional lability observed during the experiment. The finding of no significant VAS Arousal differences indicates that both groups experienced similar levels of arousal on the Active-Sleepy dimension. Within subjects ratings for the VAS for Stress, Arousal and Hedonic Tone indicate that both groups found the unpleasant condition to be more worrying, more arousing and more aversive, than either the neutral or pleasant conditions.

The psychological findings indicate stress was greater in the high anxiety group compared with controls, where overall greater negative emotional lability was observed across the conditions. That physiological and psychological changes occurred in the absence of autonomic group differences highlights the important role that interpretation has in the experience of felt-arousal; the same level of arousal can mean different things to different people. In the present study, this phenomenon was observed in the responses of the high/low anxiety groups where their responses could be characterised as arousal-avoiding/-seeking, respectively. This finding supports the telic/paratelic distinction that is central to reversal theory (Apter, 1982) and provides further evidence of a relationship between telic dominance and trait-anxiety (e.g., Baker, 1988; Lafreniere et al., 1993; Martin et al., 1987). That the observed changes in felt-arousal by the high anxiety group were interpreted as being negative or unpleasant reflects an underlying inability to reverse into their preferred low arousal state (*relaxation*). This supports the proposition that inhibited reversal may underlie chronic anxiety (Apter, 1982).

Foa and Kozac (1986) have argued that a lack of physiological response during the experience of negative emotional material indicates that the fear structure stored in memory has not been accessed. It has been suggested that somatic-anxiety might be suppressed by worry under threatening conditions (Borkovec & Hu, 1990; Mathews, 1990). In the present study because the opportunity to decrease tension-stress through performance effort was not available, it is possible that high anxiety participants engaged in worry instead. Scores from the self-report VAS Stress scale supports this view in that the high anxiety group reported being significantly more *worried* than controls. Given that a range of psychological changes in emotions or feelings took place in the high anxiety group in the absence of autonomic differences, this indicates this group may react more to psychological than somatic symptoms. This view is supported by a report by Wientjes and Grossman (1994) where inter-individual associations between anxiety, HR, psychosomatic symptoms, and end-tidal CO_2, revealed that anxiety was more closely associated with psychological rather than somatic symptoms

Whereas the psychological ratings (i.e., TESI, VAS) and physiological responses (i.e., TH% contribution, V_{MIN}) indicated the positive and negative stimuli were well differentiated, the differentiation between the neutral and pleasant stimuli was poor. This indicates the stimuli did not produce different emotions or differences in hedonic tone for the pleasant and neutral conditions. This finding supports the use of independent hedonic tone measures to differentiate emotions in psychophysiological studies, particularly when using neutral and positive conditions. The finding of no differentiation between neutral and positive conditions is at variance with other studies, especially by the developers of the IAPS, which report physiological (i.e., eye-blink startle response) and psychological ratings of hedonic tone (i.e., pleasure) differentiating neutral and pleasant (and unpleasant) stimuli (e.g., Bradley, Cuthbert, & Lang, 1991; Bonnet, Bradley, Lang, & Requin, 1995; McManus, Bradley, Berg, Cuthbert, & Lang, 2001). These differences in discrimination of neutral and pleasant stimuli, particularly in hedonic tone, may be due to underlying group differences in anxiety or arousal in the participants, or to differences in the psychometric properties of the scales used to measure hedonic tone.

Conclusion

Overall, the psychological indices were more consistent and sensitive to group differences and conditions than the physiological measures. The respiratory results provide evidence of the relationship between respiratory physiology and the domain of psychology, where the finding that TH mode breathing was greater in the high anxiety group indicates that increased TH mode breathing is implicated in GAD.

Considering that passively-attended pleasant, neutral and unpleasant events (experimental conditions) are a part of everyday life, it can be assumed that trait-anxious individuals are more prone to emotions such as anxiety, anger, sullenness, and reduced relaxation in the course of daily life, than are their counterparts. The observed physical and psychological changes may in turn influence the interpretation of life events as being more unpleasant, which may negatively reinforce the GAD tendency to worry. A further study could measure end-tidal CO_2 to determine if the hyperventilation criterion was being met by trait-anxious individuals under these conditions. At the same time, TESI transactional variables could be used to assess the impact of felt-gain or loss on trait-anxious participants while attending to affective stimuli.

The physiological and psychological findings of this study raise possibilities that are applicable to self-regulatory and clinical contexts. Increased TH mode breathing in the high anxiety group in response to all stimuli indicates that self-regulatory breathing activities may benefit GAD sufferers. By learning how to breathe more slowly and deeply (using the diaphragm), unpleasant psychosomatic symptoms may be reduced (Boiten et al., 1994; Fried, 1987, 1993; Ley & Timmins, 1994). The finding that trait-anxious individuals demonstrate inhibited reversal (Apter, 1982) suggests that GAD clients may benefit when clinicians help them to reach an understanding of how they maintain a state of unpleasant high arousal (telic dominance). Additionally, the reversal theory perspective offers a systematic framework to plan suitable interventions (Apter, 1989). Where arousal reduction would normally be presented as an intervention for chronic anxiety, an alternative would be to maintain the high arousal level and reverse into the pleasant paratelic state of excitement. The client may also benefit from understanding that increased negative emotional lability is likely to occur when efforts to reduce tension-stress are not available.

References

Allen, M. T., & Crowel, M. D. (1989). Patterns of autonomic response during laboratory stressors. *Psychophysiology, 26*, 603-614.

Allen, M. T., & Crowel, M. D. (1990). The effects of paced respiration on cardiopulmonary responses to laboratory stressors. *Journal of Psychophysiology, 4*, 357-368.

Allen, M. T., Sherwood, A., & Obrist, P. A. (1986). Interactions of respiratory and cardiovascular adjustments to behavioral stressors. *Psychophysiology, 23*, 523-541.

American Psychiatric Association (1987). *Diagnostic and Statistical Manual of Mental Disorders* (3rd ed.). Washington, DC: Author.

American Psychiatric Association (1994). *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.). Washington, DC: Author.

Ancoli, S., & Kamiya, J. (1980). Respiratory patterns during emotional expression. *Biofeedback and Self-Regulation, 5,* 356.

Ancoli, S., Kamiya, J., & Ekman, P. (1979). Psychophysiological differentiation of positive and negative affects. *Biofeedback and Self-Regulation, 4,* 242.

Apter, M. J. (1982). *The experience of motivation: The theory of psychological reversals.* London: Academic Press.

Apter, M. J. (1988). Reversal theory as a theory of the emotions. In M. J. Apter, & M. Cowles (Eds.), *Progress in reversal theory* (pp. 43-62). Amsterdam: North Holland.

Apter, M. J. (1989). *Reversal theory: Motivation, emotion and personality.* London: Routledge.

Baker, J. (1988). Stress appraisals and coping in everyday life. In M. J. Apter, J. H. Kerr, & M. Cowles (Eds.), *Progress in reversal theory* (pp. 117-128). Amsterdam: North Holland.

Bass, C., & Gardner, W. N. (1985). Respiratory and psychiatric abnormalities in chronic symptomatic hyperventilation. *British Medical Journal, 290*, 1387-1390.

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Respiratory sinus arrhythmia: Autonomic origins, physiological mechanisms, and psychophysiological implications. *Psychophysiology, 30*, 183-196.

Boiten, F. A. (1998). The effects of emotional behaviour on components of the respiratory cycle. *Biological Psychology, 49*, 29-51.

Boiten, F. A., Fridja, N. H., & Wientjes, C. J. E. (1994). Emotions and respiratory patterns: review and critical analysis. *International Journal of Psychophysiology, 17*, 103-128.

Bonn, J. A., Redhead, C. P. A., & Timmons, B. H. (1984). Enhanced adaptive behavioural response in agoraphobic patients pretreated with breathing retraining. *The Lancet, 2*, 665-669.

Bonnet, M., Bradley, M. M., Lang, P. J., & Requin, J. (1995). Modulation of spinal reflexes: Arousal, pleasure, action. *Psychophysiology, 32*, 367-372.

Borkovec, T. D., & Hu, S. (1990). The effect of worry on cardiovascular response to phobic imagery. *Behaviour Research and Therapy, 28*, 69-73.

Bradley, M. M., Cuthbert, B. N., & Lang, P. J. (1991). Startle and emotion: Lateral acoustic stimuli and the bilateral blink. *Psychophysiology, 28*, 285-295.

Brown, T. A., O'Leary, T. A., & Barlow, D. H. (1993). Cognitive-behavioural treatment of generalised anxiety disorder. In D. H. Barlow (Ed.), *Clinical handbook of psychological disorders* (pp. 137-188) (2nd ed.). New York: Guilford Publications.

Buckholtz, I. (1994). Breathing, voice, and movement therapy: Applications to breathing disorders. *Biofeedback and Self-Regulation, 19,* 141-153.

Cacioppo, J. T., & Petty, R. E. (1982). *Perspectives in cardiovascular psychophysiology.* New York: Guilford Press.

Cappo, B. M., & Holmes, D. S. (1984). The utility of prolonged respiratory exhalation for reducing physiological and psychological arousal in non-threatening and threatening situations. *Journal of Psychosomatic Research, 28,* 265-273.

Chadha, T. S., Watson, H., Birch, S., Jenouri, G. A., Schneider, A. W., Cohn, M. A., & Sackner, M. A. (1982). Validation of respiratory inductive plethysmography using different calibration procedures. *American Review of Respiratory Disorders, 125,* 644-649.

Clark, M. E., & Hirschman, R. (1994). Effects of paced respiration on anxiety reduction in a clinical population. *Biofeedback and Self-Regulation, 19,* 273-284.

Clark, D. M., Salkovskis, P. M., & Chalkley, A. J. (1985). Respiratory control as a treatment for panic attacks. *Journal of Behavioral Therapy & Experimental Psychiatry, 16,* 23-30.

Clausen, J. (1951). Respiration movement in normal, neurotic and psychotic subjects. *Acta Psychiatrica Et Neurologia, 68,* 1-74.

Davis, M., Montgomery, I. M., & Wilson, G. V. (in press). Worry and heart rate variables relationships under challenge.

Faulkner, W. B. (1941). Effects of the emotions on diaphragmatic function. *Psychosomatic medicine, 3,*187-189.

Foa, E. B., & Kozac, M. J. (1986). Emotional processing and fear: Exposure to corrective information. *Psychological Bulletin, 99*, 20-35.

Fried, R. (1987). *The hyperventilation syndrome - Research and clinical treatment.* Baltimore: John Hopkins University Press.

Fried, R. (1993). The role of respiration in stress and stress control: Towards a theory of stress as a hypoxic phenomenon. In P. M. Lehrer, & R. L. Woolfolk (Eds.), *Principles and practice of stress management* (pp. 301-331). New York: Guilford Press.

Gribbin, H. R. (1983). Using body surface movements to study breathing. *Journal of Medical Engineering & Technology*, *5,* 217-223.

Grossman, P. (1983). Respiration, stress, and cardiovascular function. *Psychophysiology; 20,* 284-300.

Grossman, P., DeSwart, J. C. G., & Defares, P. B. (1985). A controlled study of a breathing therapy treatment of hyperventilation syndrome. *Journal of Psychosomatic Research Abstract*, *29*: 97.

Grossman, P., & Svebak, S. (1987). Respiratory sinus arrhythmia as an index of parasympathetic cardiac control during active coping. *Psychophysiology*, *24*, 28-235.

Grossman, P., & Wientjes, C. J. E. (1989). Respiratory disorders: Asthma and hyperventilation syndrome. In G. Turpin (Ed.), *Handbook of Clinical Psychophysiology* (pp. 519-554). Chichester: Wiley

Haas, S. S. (1980). Relationships between individual differences in personality and respiratory behavior: An exploratory study. *Dissertation Abstracts International, 41,* 1483-B

Haas, S. S., Axen, H., Ehrlichman, H. E., & Haas, F. (1980). Relationships between personality characteristics and respiratory behavior. *The Physiologist, 23,* 74.

Hazlett, R. l., McLeod, D. R., & Hoehn-Saric, R. (1994). Muscle tension in generalised anxiety disorder: Elevated muscle tonus or agitated movement. *Psychophysiology, 31*, 189-195.

Hirsch, J. A., & Bishop, B. (1981). Respiratory sinus arrhythmia in humans: How breathing patterns modulate heart rate. *American Journal of Physiology, 241,* H620-H629.

Hoehn-Saric, R., & McLeod, D. R. (1988). The peripheral nervous system: Its role in normal and pathological anxiety. *Psychiatric Clinics of North America, 11,* 375-395.

Hoehn-Saric, R., McLeod, D. R., & Zimmerli, W. D. (1989). Somatic manifestations in women with generalized anxiety disorder. *Archives of General Psychiatry,* 46, 1113-1119.

Howard, R. (1988). Telic dominance, personality and coping. In M. J. Apter, & M. Cowles (Eds.). *Progress in reversal theory* (pp. 129-141). Amsterdam: North Holland.

Huey, S. R., & West, S. G. (1983). Hyperventilation: Its relation to symptom experience and to anxiety. *Journal of Abnormal Psychology, 92,* 422-432.

King, M. G., Stanley, G. V., & Burrows, G. D. (1987). Stress: Theory and practice. Sydney: Grune & Stratton.

Konno, K., & Mead, J. (1967). Measurement of the separate volume changes of rib cage and abdomen during breathing. *Journal of Applied Physiology, 22*, 407-422.

Lafreniere, K. D., Gillies, L. A., Cowles, M. P., & Toner, B. B. (1993). Arousability and telic dominance. In J. H. Kerr, S. Murgatroyd, & M. J. Apter (Eds.), *Advances in reversal theory* (pp. 257-266). Amsterdam: Swets & Zeitlinger.

Landis, C. (1926). Studies of emotional reactions. V. Severe emotional upset. *Journal of Comparative Psychology*, *6*, 221-242.

Lane, J. D., Adcock, A., & Burnett, R. E. (1992). Respiratory sinus arrhythmia and cardiovascular responses to stress. *Psychophysiology*, *29*, 461-470.

Lang, P. J., Ohman, A., & Vaitl, D. (1988). *The international affective picture system* (photographic slides). Gainsville: Center for Research in Psychophysiology, University of Florida.

Lehrer, P. M., & Woolfolk, R. L. (1993). *Principles and practice of stress management* (2nd ed.). New York: Guilford Press.

Lehrer, P. M., & Woolfolk, R. L. (1994). Respiratory system involvement in western relaxation and self-regulation. In B. H. Timmins, & R. Ley (Eds.), *Behavioral and psychological approaches to breathing disorders* (pp. 191-200). New York: Plenum Press.

Ley, R., & Yelich, G. (1998). Fractional end-tidal CO_2 as an index of the effects of stress on math performance and verbal memory of test-anxious adolescents. *Biological Psychology, 49*, 83-94.

Lyonfields, J. D., Borkovec, T. D., & Thayer, J. F. (1995). Vagal tone in generalized anxiety disorder and the effects of aversive imagery and worrisome thinking. *Behaviour Therapy*, *26*, 457-466.

Mador, M. J., & Tobin, M. J. (1991). Effect of alterations in mental activity on the breathing pattern in healthy subjects. *American Review of Respiratory Disorders, 144*, 481-487.

Martin, R. A., Kuiper, N. A., Olinger, L. J., & Dobbin, J. (1987). Is stress always bad? Telic verses paratelic dominance as a stress moderating variable. *Journal of Personality and Social Psychology, 53*, 970-982.

Masaoka, Y., & Homma, I. (1997). Anxiety and respiratory patterns: Their relationship during mental stress and physical load. *International Journal of Psychophysiology, 27*, 153-159.

Mathews, A. (1990). Why worry? The cognitive function of worry. *Behaviour Research and Therapy, 28*, 455-468.

Maxwell, S. E., & Delaney, H. D. (1989). *Designing experiments and analysing data*. Belmont, California: Wadsworth.

McManus, M. H., Bradley, M. M., Berg. W.K., Cuthbert, B.N., & Lang, P. L. (2001). Emotional reactions in children: Verbal, physiological, and behavioral responses to affective pictures. *Psychophysiology, 38*, 222-231.

Montgomery, G. T. (1994). Slowed respiration training. *Biofeedback and Self-Regulation, 19*, 211-225.

Murgatroyd, S. (1985). The nature of telic dominance. In M. J. Apter, D. Fontana, & S. Murgatroyd (Eds.), *Reversal theory: Applications and developments* (pp. 1-19). Cardiff: University College Cardiff Press.

Nathan, P. E., & Gorman, J. M. (1998). *A guide to treatments that work.* New York: Oxford University Press.

Patel, C. (1991). *The complete guide to stress management.* New York: Plenum Press.

Porges, S. W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. A polyvagal theory. *Psychophysiology, 32*, 301-318.

Rapee, R. S. (1991). Generalized anxiety disorder: A review of clinical features and theoretical concepts. *Clinical Psychology Review, 11*, 419-440.

Seuss, W. M., Alexander, A. B., Smith, D. D., Sweeney, H. W., & Marion, R. J. (1980). The effects of psychological stress on respiration: A preliminary study of anxiety and hyperventilation. *Psychophysiology, 17,* 535-540.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *State-trait anxiety inventory for adults*. California: Consulting Psychologists Press.

Svebak, S. (1975). Respiratory patterns as predictors of laughter. *Psychophysiology, 12*, 62-65.

Svebak, S. (1986). Patterns of cardiovascular-somatic-respiratory interactions in the continuous perceptual-motor task paradigm. In P. Grossman, K. Janssen, & D. Vaitl (Eds.), *Cardiorespiratory and cardiosomatic psychophysiology* (pp. 219-230). New York: Plenum Press.

Svebak, S. (1993). The development of the tension and effort-stress inventory (TESI). In J. H. Kerr, S. Murgatroyd, & M. J. Apter (Eds.), *Advances in reversal theory* (pp. 189-204). Amsterdam: Swets Zeitlander.

Svebak, S., Dalen, K., & Storfjell, O. (1981). The psychological significance of task-induced tonic changes in somatic and autonomic activity. *Psychophysiology, 18,* 403-409.

Svebak, S., & Grossman, P. (1985). The experience of psychosomatic symptoms in the hyperventilation provocation test and in non-hyperventilation tasks. *Scandinavian Journal of Psychophysiology, 26*, 327-335.

Svebak, S., Storfjell, O., & Dalen, K. (1982). The effect of a threatening context upon motivation and task-induced physiological changes. *British Journal of Psychology*, *73*, 505-512.

Svebak, S., & Murgatroyd, S. (1985). Metamotivational dominance: A multimethod validation of reversal theory constructs. *Journal of Personality and Social Psychology*, *48*, 107-116.

Thayer, J. F., Friedman, B. H., & Borkovec, T. D. (1996). Autonomic characteristics of generalized anxiety disorder and worry. *Biological Psychiatry*, *39*, 255-266.

Timmins, B. H., & Ley, R. (1994). *Behavioral and psychological approaches to breathing disorders*. New York: Plenum Press.

Tobin, M. J., Chadha, T. S., Jenouri, G., Birch, S. J., Hacik, B., Gazeroglu, H. B., & Sackner, M. A. (1983a). Breathing patterns 1: Normal subjects. *Chest*, *84*: 202-205.

Tobin, M. J., Chadha, T. S., Jenouri, G., Birch, S. J., Hacik, B., Gazeroglu, H. B., & Sackner, M. A. (1983b). Breathing patterns 2: Diseased patients. *Chest*, *84*: 286-294.

Vasey, M. W., & Thayer, J. F. (1987). The continuing problem of false positives in repeated measures ANOVA in psychophysiology: A multivariate solution. *Psychophysiology*, *24*, 479-486.

Watson, H. (1980). The technology of respiratory inductive plethysmography. In F. D. Scott, B. Raftery, & I. Goulding (Eds.), *ISAM 1979: Procedings of the Third International Symposium on Ambulatory Monitoring* (pp. 537-558). London: Academic Press.

Watson, D., & Pennebaker, J. W. (1989). Health complaints, stress and distress: Exploring the central role of negative affectivity. *Psychological Review, 98*, 234-254.

Wientjes, C. J. E. (1992). Respiration in psychophysiology: Methods and applications. *Biological Psychology, 34*, 179-203.

Wientjes, C. J. E., & Grossman, P. (1994). Respiratory psychophysiology as a discipline: Introduction to the special issue. *Biological Psychology, 49*, 1-8.

Appendix A. Psychological Ratings Inventories (Tension and Effort Stress Inventory; Visual Analogue Scales).

Tension and Effort Stress Inventory (TESI)

Experimenter use only: Participant No. Date:

Please give your answers by *circling* the appropriate figures.

A. Estimate here the degree to which you are presently experiencing the following ***moods or emotions*** in this present situation.

	Not at all						Very much
Relaxation:	1 -	2 -	3 -	4 -	5 -	6 -	7
Anxiety:	1 -	2 -	3 -	4 -	5 -	6 -	7
Excitement:	1 -	2 -	3 -	4 -	5 -	6 -	7
Boredom:	1 -	2 -	3 -	4 -	5 -	6 -	7
Placidity:	1 -	2 -	3 -	4 -	5 -	6 -	7
Anger:	1 -	2 -	3 -	4 -	5 -	6 -	7
Provocativeness:	1 -	2 -	3 -	4 -	5 -	6 -	7
Sullenness:	1 -	2 -	3 -	4 -	5 -	6 -	7

B. Estimate how you feel at ***the present moment*** by placing a cross on the line on each of the following.

Calm	______________________________	Worried
Active	______________________________	Sleepy
Pleasant	______________________________	Unpleasant

Appendix B. International Affective Picture System (IAPS).

Appendix B. *International Affective Picture System (IAPS) Slide Descriptions and Slide Numbers Used in Experiment.*

International Affective Picture System (IAPS)					
Contents: Pleasant		**Neutral**		**Unpleasant**	
Description	*Slide No.*	*Description*	*Slide No.*	*Description*	*Slide No.*
Chocolate shake	7270	Fan	7020	Snake	1070
Baby	2050	Iron	7030	Spider	1210
Women and parrots	1340	Hairdryer	7050	Angry face	2120
Cake	7200	Garbage bin	7060	Mutilation	3000
Tennis player	8120	Fork	7080	Mutilation	3170
Couple	4650	Cloth	7160	Mutilation	3100
Puppies	1710	Light	7170	Mutilation	3120
Flowers	5200	Umbrella	7150	Mutilation	3140
Sunset	5830	Building	7500	Snarling dog	3150
Outdoors	5960	Rolling pin	7000	Syringe	3200
Turkey	7320	Mushrooms	5500	Aimed gun	6200
Child and dog	2655	Basket	7010	Mutilation	3130
Couple in water	4641	Book	7090	Snake	3090
Torte'	7280	Truck	7130	Snake	1110
Skier	8190	Glass mug	7035	Aimed gun	6230
Sailboat	8080	Mushrooms	5510	Injured child	9040
Couple kiss	4653	Hammer	7160	Plane crash scene	9050
Couple kiss	4660	Hydrant	7100	Mutilation	3030

Appendix C. Statement of Informed Consent

INFORMATION SHEET

Chief Investigator: Dr. George Wilson Second Investigator: Marc Hood

The aim of this investigation is to assess participants physiological response patterns and stress reactivity to visual stimuli. Emotional and arousal changes will also be assessed. The study is a partial requirement for a Master of Psychology degree (Development and Education) for the second investigator.

Participants will be tested individually and will be required to fill out a Tension and Effort Stress Inventory and a Visual Analogue Scale before, during and after each task. Participants will be fitted with two respiratory transducer belts (to record breath patterns) and electrodes (to record other physiological responses). Physiological measurements will be taken before, during and after the tasks. The entire session will take between 70-90 minutes.

Participation in this study is voluntary, and you may withdraw at any time, without prejudice, should you so wish. The data obtained from participants will be regarded as confidential, and any subsequent publication of the data will be done without identification of individual participants.

This study has the approval of the University Ethics Committee (Human Experimentation). Any queries relating to the research may be answered by contacting Dr. George Wilson on 6226 2240, or myself (Marc Hood) on 62 951882. Concerns of an ethical nature or complaints about the manner in which the study is conducted may be directed to the Chair of the University Ethics Committee (Dr. Margaret Otlowski, on (03) 62 267569) or the Executive Officer (Ms Chris Hooper, on (03) 62 262763).

INFORMED CONSENT

"I have read the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this investigation and understand that I may withdraw at any time without prejudice. I agree that research data gathered for the study may be published provided that I cannot be identified as a subject".

Name of participant..
Signature of
participant...Date...................................

"I have explained this project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation".

Name of investigator..
Signature of
investigator... Date...

Appendix D. General Linear Model analyses of variance performed in Statistics Package for Social Sciences (SPSS).

Section A .

Repeated measures multivariate analysis of variance (MANOVA) performed for physiological variables: Thoracic percentage contribution (TH%), respiration rate (RR), heart rate (HR), respiratory sinus arrhythmia (RSA), skin conductance level (SCL), and percentage finger pulse amplitude (FPA%).

Section B.

Doubly multivariate MANOVAs for Positive and Negative Tension and Effort Stress Inventory (TESI). Follow-up repeated measures MANOVAs performed for the TESI variables: Relaxation, excitement, placidity, provocativeness, anxiety, boredom, anger, sullenness.

Section C.

Doubly multivariate MANOVAs for Visual Analogue Scales (VAS). Follow-up repeated measures MANOVAs performed for the VAS variables: Stress: Calm-worried; Arousal: Active-sleepy; Hedonic Tone: Pleasant-unpleasant.

Section A.

RC%

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. Df	Error df	Sig.	Observed Power
Condition	.238	5.618	2.000	36.000	.008	.828
Condition X Group	.223	5.168	2.000	36.000	.011	.794

Between Subjects

Source	Type III Sum of squares	Df	Mean Square	F	Sig.	Observed Power
GROUP	3328.245	1	3328.245	8.590	.006	.814

RR

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. Df	Error df	Sig.	Observed Power
Condition	.071	1.375	2.000	36.000	.266	.276
Condition X Group	.138	2.874	2.000	36.000	.070	.527

Between Subjects

Source	Type III Sum of squares	Df	Mean Square	F	Sig.	Observed Power
Group	22.695	1	22.695	1.069	.308	.172

V_{MIN}:

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.060	1.143	2.000	36.000	.330	.235
Condition X Group	.183	4.029	2.000	36.000	.026	.682

Between Subjects

Source	Type III Sum of squares	Df	Mean Square	F	Sig.	Observed Power
GROUP	55.509	1	55.509	.673	.417	.126

HR

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.023	.423	2.000	36.000	.659	.113
Condition X Group	.104	2.081	2.000	36.000	.140	.400

Between Subjects

Source	Type III Sum of squares	Df	Mean Square	F	Sig.	Observed Power
GROUP	22.452	1	22.452	.067	.797	.057

RSA

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.100	2.006	2.000	36.000	.149	.387
Condition X Group	.030	.561	2.000	36.000	.575	.136

Between Subjects

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Observed Power
GROUP	11.005	1	11.005	.121	.730	.063

SCL

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.049	.932	2.000	36.000	.403	.199
Condition X Group	.005	.087	2.000	36.000	.917	.062

Between Subjects

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Observed Power
GROUP	273.553	1	273.553	.379	.542	.092

FPA%

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.085	1.681	2.000	36.000	.201	.330
Condition X Group	.014	.262	2.000	36.000	.771	.088

Between Subjects

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Observed Power
GROUP	83.304	1	83.304	.542	.466	.111

Section B.

Positive TESI Emotions:

Doubly Multivariate MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.358	10.486	2.000	36.000	.000	.977
Condition X Group	.029	.546	2.000	36.000	.584	.133
PositiveTESI	.889	93.070	2.000	36.000	.000	1.000
Positive TESI x Group	.199	2.895	2.000	36.000	.049	.640
Condition x Positive TESI	.553	6.59	2.000	36.000	.000	.997
Condition x Positive TESI x Group	.141	.874	2.000	36.000	.524	.293

Relaxation

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.486	17.026	2.000	36.000	.000	.999
Condition X Group	.009	.160	2.000	36.000	.853	.073

Between Subjects

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Observed Power
GROUP	21.778	1	21.778	6.322	.015	.688

Excitement

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.045	.839	2.000	36.000	.440	.183
Condition X Group	.929	1.370	2.000	36.000	.267	.276

Between Subjects

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Observed Power
GROUP	1.040	1	10.40	.363	.550	.010

Placidity

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.289	7.320	2.000	36.000	.002	.918
Condition X Group	.023	.415	2.000	36.000	.664	.112

Between Subjects

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Observed Power
GROUP	6.978	1	6.978	1.367	.250	.207

Provocativeness

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.274	6.809	2.000	36.000	.003	.897
Condition X Group	.126	2.605	2.000	36.000	.088	.486

Between Subjects

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Observed Power
GROUP	3.509	1	3.509	3.860	.057	.482

Negative TESI Emotions:

Doubly Mulitvariate MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.229	5.334	2.000	36.000	.009	.807
Condition X Group	.028	.523	2.000	36.000	.597	.129
NegativeTESI	.617	18.758	2.000	36.000	.000	1.000
Negative TESI x Group	.156	2.161	2.000	36.000	.110	.503
Condition x Negative TESI	.504	5.418	2.000	36.000	.001	.986
Condition x Negative TESI x Group	.079	.458	2.000	36.000	.834	.163

Anxiety

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.490	17.325	2.000	36.000	.000	1.000
Condition X Group	.018	.325	2.000	36.000	.725	.098

Between Subjects

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Observed Power
GROUP	10.802	1	10.802	4.088	.050	.504

Boredom

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.229	5.348	2.000	36.000	.009	.808
Condition X Group	.000	.009	2.000	36.000	.991	.051

Between Subjects

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Observed Power
GROUP	5.204	1	5.204	1.196	.281	.187

Anger

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.124	2.553	2.000	36.000	.092	.487
Condition X Group	.082	1.601	2.000	36.000	.216	.316

Between Subjects

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Observed Power
GROUP	6.878	1	6.878	5.440	.025	.622

Sullenness

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.207	4.686	2.000	36.000	.016	.751
Condition X Group	.022	.408	2.000	36.000	.668	.111

Between Subjects

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Observed Power
GROUP	8.984	1	8.984	4.442	.042	.537

Section C.

Visual Analogue Scales (VAS)

Doubly Multivariate MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.474	16.242	2.000	36.000	.000	.999
Condition X Group	.135	2.814	2.000	36.000	.073	.518
VAS	.561	22.964	2.000	36.000	.000	1.000

Between Subjects

Source	Type III Sum of squares	Df	Mean Square	F	Sig.	Observed Power
GROUP	13.694	1	13.694	3.365	.075	.431

Stress: Calm-Worried

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.371	10.604	2.000	36.000	.000	.983
Condition X Group	.012	.212	2.000	36.000	.810	.081

Between Subjects

Source	Type III Sum of squares	Df	Mean Square	F	Sig.	Observed Power
GROUP	28.227	1	28.227	6.845	.013	..722

Arousal: Active-Sleepy

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.433	13.736	2.000	36.000	.000	.997
Condition X Group	.017	.321	2.000	36.000	.728	.097

Between Subjects

Source	Type III Sum of squares	Df	Mean Square	F	Sig.	Observed Power
GROUP	9.731	1	9.731	1.564	.219	.230

Hedonic Tone: Pleasant-Unpleasant

Repeated Measures MANOVA (Pillai's Trace)

Effect	Value	F	Hypoth. df	Error df	Sig.	Observed Power
Condition	.412	12.592	2.000	36.000	.000	.994
Condition X Group	.019	.358	2.000	36.000	.702	.103

Between Subjects

Source	Type III Sum of squares	Df	Mean Square	F	Sig.	Observed Power
GROUP	17.776	1	17.776	5.506	.024	.628